Draft Final
Remedial Investigation Report

Culebra Island Site
Puerto Rico

Terrestrial Areas of:

MRS 06 – Artillery Firing Area

MRS 08 – Cayo Norte Impact Area

MRS 09 – Soldado Point Mortar and Bombing Area

MRS 10 – Defensive Firing Area No. 1

MRS 11 – Defensive Firing Area No. 2

MRS 13 – Cayo Luis Pena Impact Area

FUDS Project No. I02PR0068

Prepared for:
U.S. Army Corps of Engineers, Jacksonville District
701 San Marco Boulevard
Jacksonville, FL 32207
&
U.S. Army Engineering and Support Center, Huntsville
4820 University Square
Huntsville, Alabama 35816

Contract: W912DY-04-D-0006
Task Order: 0022

July 2014

USA Environmental, Inc.

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ACRONYMS AND ABBREVIATIONS

AAA	Autoridad de Acueductos y Alcantarillados
ARAR	Applicable, Relevant, and Appropriate Requirement
ASR	archive search report
bgs	below ground surface
BSI	Blind Seed Item
BTV	Background Threshold Value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CESAJ	U.S. Army Corps of Engineers Jacksonville District
CFR	Code of Federal Regulations
CHE	Chemical Warfare Materiel Hazard Evaluation
COC	Chain of Custody
COD	Certificate of Destruction
COPC	Contaminant of Potential Concern
CRIM	Center for Collection of Municipal Revenues
CRREL	Cold Regions Research and Engineering Laboratory
CSEM	conceptual site exposure model
CSM	conceptual site model
CWM	Chemical Warfare Materiel
DERP	Defense Environmental Restoration Program
DGM	Digital Geophysical Mapping
DGPS	Differential Global Positioning System
DNER	(Puerto Rico) Department of Natural and Environmental Resources
DoD	Department of Defense
DOI	Department of Interior
DON	Department of the Navy
DQO	data quality objective
DVR	Data Validation Report
EHE	Explosive Hazard Evaluation
ESL	Ecological Screening Level
EOD	explosive ordnance disposal
EPA	Unites States Environmental Protection Agency
EPC	Exposure Point Concentration
ER	Engineer Regulation
ERDC	Engineer Research and Development Center
ESE	Environmental Science and Engineering, Inc.
ESP	Explosives Siting Plan

ESQD	Explosive Safety Quantity-Distance
ESV	ecological screening value
FAA	Federal Aviation Administration
FDE	Findings and Determination of Eligibility
FLEX	Fleet Landing Exercise
FS	Feasibility Study
FSP	Field Sampling Plan
FUDS	Formerly Used Defense Site
FWS	U.S. Fish and Wildlife Service
GIS	geographic information system
GPO	Geophysical Prove-Out
GSV	Geophysical System Verification
HA	Hazard Assessment
HE	high explosive
HHE	Health Hazard Evaluation
HQ	hazard quotient
HTW	hazardous and toxic waste
HVAR	High Velocity Aircraft Rocket
INPR	Inventory Project Report
ISO	Industry Standard Object
IVS	Instrument Verification Strip
LANL	Los Alamos National Laboratory
LDC	Laboratory Data Consultants, Inc.
LUC	Land Use Control
Marines	U.S. Marine Corps
MC	munitions constituent
MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
mg/kg	milligram per kilogram
mm	millimeter
MMRP	Military Munitions Response Program
MPPEH	Material Potentially Presenting an Explosive Hazard
MRS	munition response site
MRSPP	Munitions Response Site Prioritization Protocol
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Navy	U.S. Navy

NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NHA	National Heritage Area
NHL	National Historic Landmark
NMFS	National Marine Fisheries Service
No.	number
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRIS	National Register Information System
NWP	Northwest Peninsula
NWRS	National Wildlife Refuge System
OB/OD	Open Burn / Open Detonation
PCOPC	preliminary contaminants of potential concern
PD	Point Detonating
PDA	Personal Digital Assistant
PEP	Propellant, energetic, and pyrotechnics
PRASA	Puerto Rico Aqueduct and Sewer Authority
PREQB	Puerto Rico Environmental Quality Board
PRG	preliminary remediation goal
PSV	Preliminary Screening Value
PWS	Performance Work Statement
QA	quality assurance
QC	quality control
QSM	Quality System Manual
RA	Risk Assessment
RAB	Restoration Advisory Board
RAC	risk assessment code
RI	Remedial Investigation
RI/FS	remedial investigation and feasibility study
ROE	right of entry
RSL	Regional Screening Level
RTI	RTI Laboratories
SAP	Sampling and Analysis Plan
SHPO	State Historic Preservation Office
SI	site inspection
SLERA	screening level ecological risk assessment
SLRA	screening level risk assessment
SOP	Standard Operating Procedure

SSL	soil screening level
SUXOS	Senior Unexploded Ordnance Supervisor
TBC	To Be Considered
TCRA	time-critical removal action
TESS	Threatened and Endangered Species System
TES	Timberline Environmental Services, Inc.
TPP	technical project planning
U.S.	United States
USA	USA Environmental, Inc.
USACE	U.S. Army Corps of Engineers
USAESCH	U.S. Army Corps of Engineers, Engineering and Support Center, Huntsville
USC	U.S. Code
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USCG	United States Coast Guard
USGS	U.S. Geological Survey
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Specialist
VOC	Volatile Organic Compound
WP	Work Plan

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GLOSSARY OF TERMS

anomaly Any item that deviates from the expected subsurface ferrous and non-ferrous material at a site (i.e., pipes, power lines, etc.).

military munitions All ammunition products and components produced for or used by the armed forces for national defense and security, including ammunition products or components under the control of the Department of Defense, the Coast Guard, the Department of Energy, and the National Guard. The term includes confined gaseous, liquid, and solid propellants; explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries, including bulk explosives and chemical warfare agents; chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges; and devices and components thereof.

munitions and explosives of concern (MEC) Military munitions that may pose unique explosives safety risks, including UXO, discarded military munitions, or munitions constituents present in high enough concentrations to pose an explosive hazard.

munitions constituents (MC) Any materials originating from unexploded ordnance, discarded military munitions, or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions.

munitions debris Remnants of munitions (e.g., penetrators, projectiles, shell casings, links, fins) remaining after munitions use, demilitarization, or disposal.

munitions response Response actions, including investigation, removal actions, and remedial actions, to address the explosive safety, human health, or environmental risks presented by unexploded ordnance, discarded military munitions, or munitions constituents, or to support a determination that no removal or remedial action is required.

munitions response site (MRS) A discrete location within an MRA that is known to require a munitions response.

projectile Object projected by an applied force and continuing in motion by its own inertia. This includes bullets, bombs, shells, grenades, guided missiles, and rockets.

unexploded ordnance (UXO) Military munitions that have been primed, fuzed, armed, or otherwise prepared for action; that have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installation, personnel, or material; and that remain unexploded whether by malfunction, design, or any other cause.

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CHAPTER 1. EXECUTIVE SUMMARY

A Remedial Investigation (RI) is not a removal action; rather it is used to determine the nature and extent of the munitions-related contamination in order to develop recommendations for the next action to be taken, if any. The RI and the associated Feasibility Study (FS) Reports for the Culebra Island Munition Response Sites (MRSs) have been prepared as separate volumes consisting of two reports – the RI Report and the FS Report. The two reports address the terrestrial areas in six of the 14 identified MRSs associated with Culebra Island. The water portions will be evaluated in a separate report. The six MRSs evaluated in this RI on Culebra Island include MRS 06, MRS 08, MRS 09, MRS 10, MRS 11, and MRS 13. The other MRSs are addressed under separate contracts. The conclusions and recommendations of this report apply only to the terrestrial portions of the six MRSs addressed in the RI.

1.1 BACKGROUND

In 1898, the Spanish American War concluded and the Kingdom of Spain ceded all of Puerto Rico to include Culebra and its adjacent cays to the U.S. Shortly after, in 1900, President Theodore Roosevelt placed Culebra under the jurisdiction of the Department of the Navy (DON). In 1903, the Navy acquired approximately 4,200 acres of land by transfer and purchase; further donations, transfers, and leases between 1939 and 1965 brought the total land acquired to approximately 4,800 acres. Although portions of the site were never formally acquired, military use included the entire Island of Culebra and all surrounding cays. The Navy retained 87.5 acres near Flamenco Point that are not eligible for the Formerly Used Defense Site (FUDS) program. The Northwest Peninsula (NWP) Target Area was also deemed ineligible for the FUDS program per Public Law 93-166 (Military Construction Authorization Act, 1974). The 2005 revised Findings and Determination of Eligibility report states that the site, except for 87.5 acres recently transferred from the control of the Navy and the 408 acres of the NWP (1982 Quit Claim Deed), has been determined to be formerly used by the Department of Defense (DoD) (USACE, 2005). All military use of the island was terminated in 1975. In summary, the Island of Culebra, nearby cays, and surrounding water were used between 1902 and 1975 for training and live fire of bombs, mortars, rockets, torpedoes, projectiles, and small arms. Figure 1-1 shows the location of Culebra and the MRSs. Figure 1-2 shows more detail on the MRSs and provides land and water acreages. Figure 1-3, comprised of Plate 2 of the Archives Search Report (ASR) shows areas of historical Department of Defense (DoD) activity.

During the Site Inspection (SI) completed by Parsons in 2007, the Culebra Island MRS was evaluated for Munitions and Explosives of Concern (MEC) and Munitions Constituents (MC). The MRSs included in the SI were established in the Revised Inventory Project Report (INPR) that was completed in June 2005 [U.S. Army Corps of Engineers (USACE), 2005]. The Revised INPR further defined the military use of the Island of Culebra and divided the original site, Property No I02PR0068, into 14 separate MRSs. Of the 14 MRSs identified in the Revised INPR, six MRSs were included for further evaluation under Contract W912DY-04-D-0006, Task Order 0022:

- MRS 06 – Artillery Firing Area (Terrestrial)
- MRS 08 – Cayo Norte Impact Area (Terrestrial)
- MRS 09 – Soldado Point Mortar and Bombing Area (Terrestrial)
- MRS 10 – Defensive Firing Area No. 1 (Terrestrial)
- MRS 11 – Defensive Firing Area No. 2 (Terrestrial)
- MRS 13 – Cayo Luis Pena Impact Area (Terrestrial).

The SI recommended conducting an RI/FS for all six MRSs.

This RI Report addresses the characterization of the former Culebra Island MRSs for the purpose of developing and evaluating effective remedial alternatives. The characterization was designed to identify hazards related to MEC and risks and hazards associated with MC. The FS Report, produced as a separate document, will develop and evaluate remedial alternatives and provide recommended actions for the evaluated areas of the site.

Chapter 2 provides descriptions for each of the Culebra Island MRSs included in this RI. The Culebra Island MRSs included in this RI are shown in Figure 1-2.

As part of the Technical Project Planning (TPP) process, the TPP Team developed a Conceptual Site Model (CSM) for each of the six Culebra Island MRSs addressed under this contract. The CSMs were developed in support of the TPP process and are presented in Chapter 3. A CSM is a dynamic document that is to be evaluated and revised each time new information is received. Since an SI was completed for this site, the initial CSM for this RI was based on the SI findings (Parsons, 2007).

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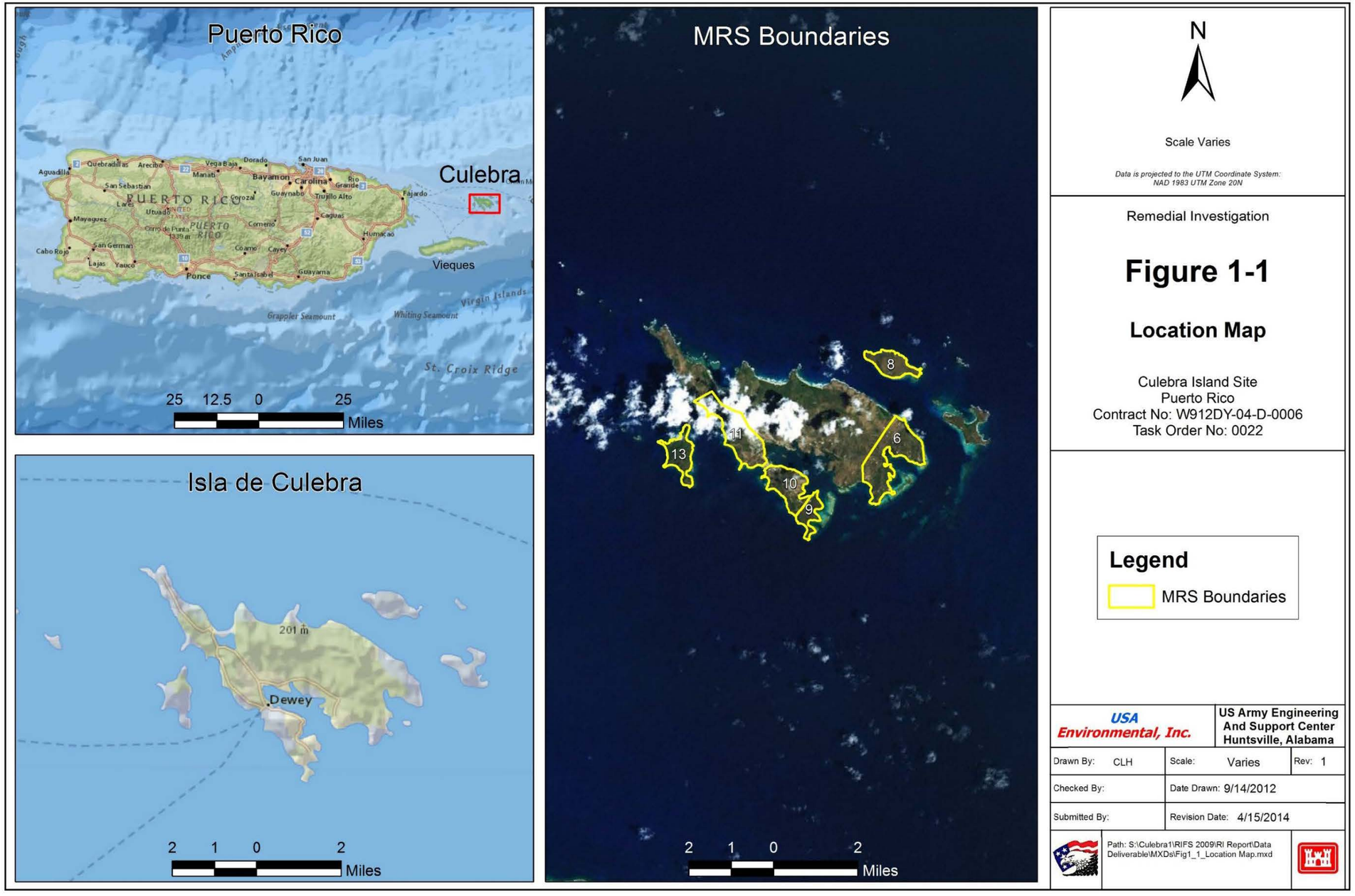

Figure 1-1: Location Map

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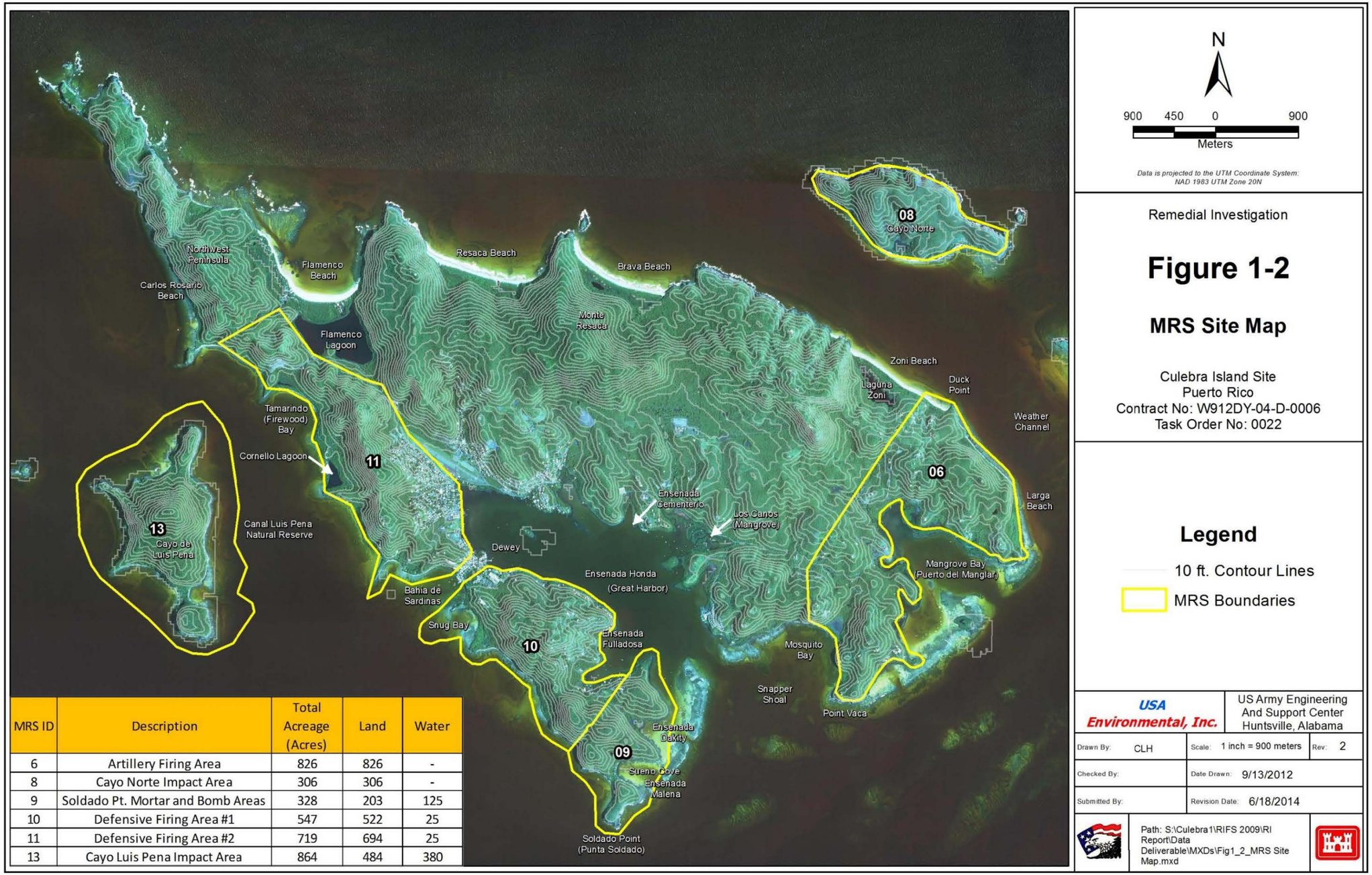

MRS ID	Description	Total Acreage (Acres)	Land	Water
6	Artillery Firing Area	826	826	-
8	Cayo Norte Impact Area	306	306	-
9	Soldado Pt. Mortar and Bomb Areas	328	203	125
10	Defensive Firing Area #1	547	522	25
11	Defensive Firing Area #2	719	694	25
13	Cayo Luis Pena Impact Area	864	484	380

Figure 1-2: Culebra Island MRS Map

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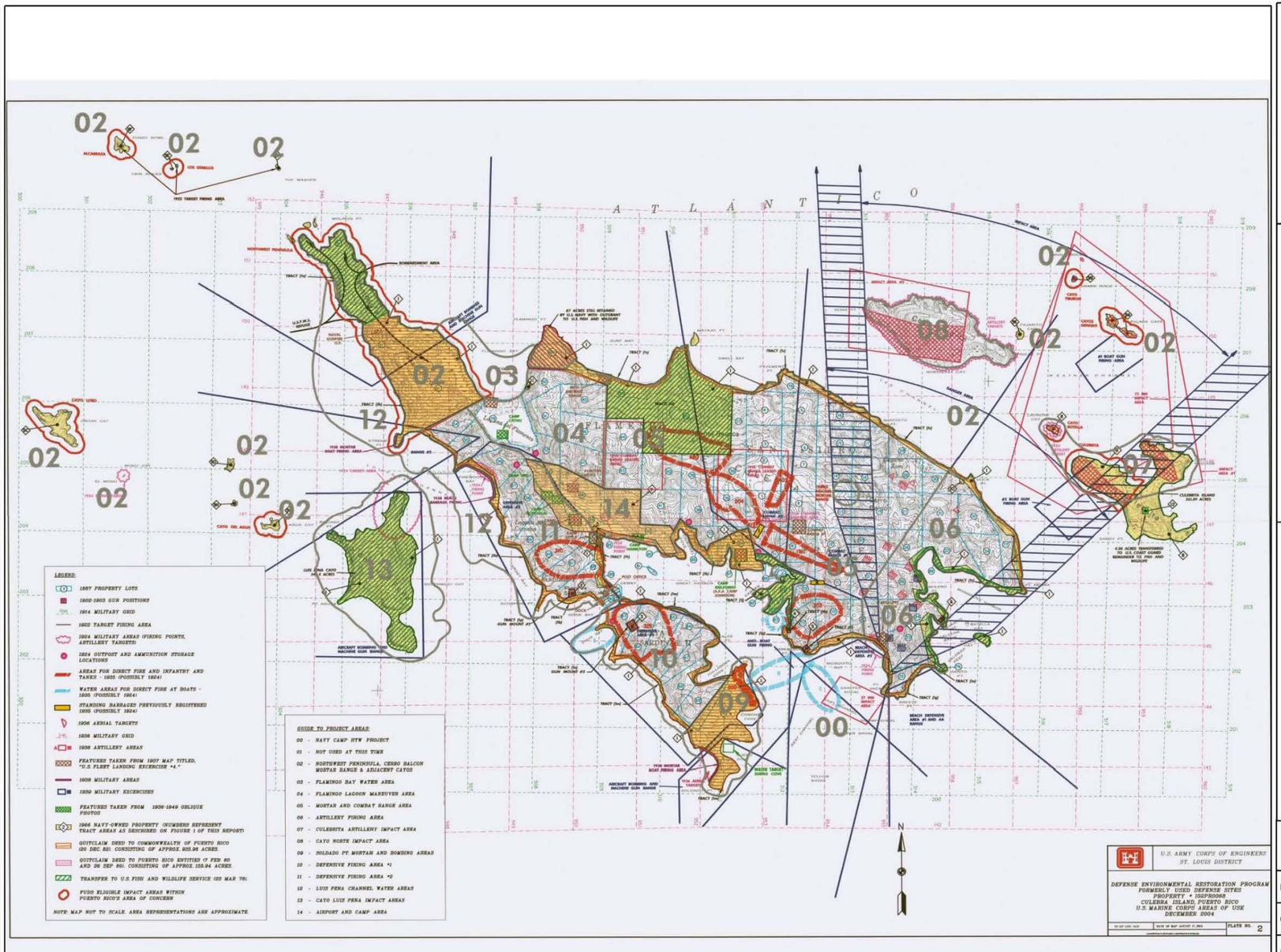

Figure 1-3: Plate 2 from Supplemental Archives Search Report

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1.2 REMEDIAL INVESTIGATION

The initial Culebra Island RI field work was conducted between May and October 2011. In 2013, a groundwater investigation involving a well survey and groundwater sampling was added to the project. Field work was conducted in September and December 2013. The RI included the following field investigation activities:

- Digital Geophysical Mapping (DGM) (Transects and Grids)
- Anomaly Reacquisition and Intrusive Investigation (Grids)
- Analog Mag-and-Dig Investigations (Beach areas and accessible trails)
- Demolition and Disposal
- Environmental Sample Collection (Soil, Sediment, Surface Water, and Groundwater)

Details pertaining to each field investigation activity are provided in Chapter 4. Table 1-1 summarizes the anomaly investigation results for the RI. Table 1-2 provides the environmental sampling summary for the RI.

Table 1-1: Summary of RI Intrusive Investigation Results

Investigation Type/MRS	Number of Locations						
	MEC	MD	Small Arms	Other Debris	Hot Rock	Seed Items	Total
DGM Anomalies							
MRS 06	0	4	0	74	310	17	405
MRS 08	0	12	0	1	201	8	222
MRS 09	0	8	0	21	205	14	248
MRS 10	0	0	0	30	161	14	205
MRS 11	0	15	0	44	104	15	178
MRS 13	-	-	-	-	-	-	-
Analog Anomalies							
MRS 06	0	0	0	44	0	14	58
MRS 08	0	0	0	26	0	1	27
MRS09	2	0	0	20	0	4	26
MRS 10	0	0	0	35	0	6	41
MRS 11	0	2	0	38	0	24	64
MRS 13	0	10	2	304	72	20	408
Total	**2**	**51**	**2**	**637**	**1,054**	**137**	**1,882**

Note: MD observations from a 2009 post award Site Visit were also used in the MEC assessment, but not included here.

529 **Table 1-2: Remedial Investigation MC Sample Locations and Rationale**

MRS	Media	Number	QC	Rationale
06	Soil (Surface)	4	1	Collected in a location where MEC or MD were discovered and/or destroyed
	Groundwater	2	1	Collected from existing wells in the general vicinity of MD findings or historical DoD activity.
08	Soil (Surface)	12	2	Collected in a location where MEC or MD were discovered and/or destroyed
09	Soil (Surface)	8	2	Collected in a location where MEC/MD were discovered and/or destroyed. Sediment and Surface Water in down gradient areas from MEC/MD finds.
	Surface Water	3	1	
	Sediment	3	1	
	Groundwater	1	0	Collected from a well installed well as part of the RI in the general vicinity of where MD was discovered.
10	Soil (Surface)	0	0	No MEC or MD were discovered or destroyed in this MRS and therefore, IAW the WP, no samples were collected.
11	Soil (Surface)	28	2	Collected in a location where MEC or MD were discovered and/or destroyed.
	Groundwater	1	0	Collected from a well installed as part of the RI in the general vicinity of MD findings.
13	Soil (Surface)	32	3	Collected in a location where MEC or MD were discovered and/or destroyed.
Total		94	13	

530

531 ## 1.3 SUMMARY AND CONCLUSIONS

532 ### 1.3.1 Munitions and Explosives of Concern Risk Assessment

533 The potential for human and ecological exposure to MEC was evaluated at each of the six
534 Culebra Island MRSs as part of this RI. Chapter 4 provides details for MEC Characterization and
535 Chapter 7 provides the details of the Baseline Risk Assessment for MEC. The following
536 paragraphs and Table 1-3 summarize the MEC characterization results of the RI for each MRS.

Table 1-3: MEC Characterization Summary Table

MRS	Land Use (Current / Future)	MEC/MD Present?	FS Recommended?
MRS 06	Residential/ Residential	Yes (MD)	Yes
MRS 08	Part-Time Residential/ Residential or Resort	Yes (MD)	Yes
MRS 09	Nature Preserve, Residential / Nature Preserve, Residential	Yes (MEC and MD)	Yes
MRS 10	Residential / Residential	No	Yes
MRS 11	Mixed Residential, Landfill / Mixed Residential, Landfill	YES (MD)	Yes
MRS 13	Nature Preserve/ Nature Preserve	Yes (MD)	Yes

1.3.1.1 MRS 06 - Artillery Firing Area

The low density of the recovered munitions debris (MD) in MRS 06 is not indicative of these areas being used as target or impact areas. Firing point locations have been historically documented. MD recovered from two grids was identified as artillery primers, supporting the documented use. Other debris from two other grids was identified as fragmentation; however, a nomenclature for these items was not identified due to the small size of the fragments. One item was discovered in a grid near areas containing debris associated with residential development. The other MD item may be associated with the historical buffer areas of Cayo Botella, an adjacent target island. The potential for human receptors to encounter surface or subsurface MEC at MRS 06 is considered low; however, potential exposure to an explosive hazard cannot be completely ruled out due to the historical firing points.

1.3.1.2 MRS 08 Cayo Norte Impact Area

The anomaly density on MRS 08 is relatively low; however, there are sufficient amounts of MD to confirm the western side of MRS 08 was used as 75 mm artillery target area (from MRS 06 firing points), even if for a short period of time. No MEC or MD items were recovered along the beach areas of MRS 08. The presence of MD in the upland areas indicates the possibility for an explosive hazard to be present in MRS 08.

1.3.1.3 MRS 09- Soldado Point Mortar and Bombing Area

Two unexploded ordnance (UXO) items (Mk 25 Marine Flares) were recovered from MRS 09. Historical data provided in the Culebra ASR (USACE 1995) and Culebra ASR Supplement (USACE, 2005) for MRS 09 indicate former U.S. Marine Corps activities involving 4.2-in. mortars in the 1920s with possible aerial bombing and strafing in the 1950-60's. MD recovered from grids confirms the presence of 4.2-inch high explosive (HE) mortars given evidence of functioned M9 point detonating (PD) fuzes; however, no evidence of HE aerial bombs were recovered in MRS 09. Given the presence of expended 4.2-inch mortar fuzes, a potential for human and ecological exposure to HE MEC in MRS 09 exists.

1.3.1.4 MRS 10- Defensive Firing Area No. 1

No MD items were recovered in MRS 10 during the RI; therefore, the potential for humans to encounter MEC at the remaining areas of MRS 10 is considered low. Historical records indicate that various areas of MRS 10 were used by the Marine Corps for maneuvers; therefore, potential exposure to an explosive hazard cannot be completely ruled out.

1.3.1.5 MRS 11- Defensive Firing Area No. 2

Given the close proximity of the northern portion of MRS 11 to the NWP Bombardment Area, it was anticipated that anomaly density would be heavy, posing an elevated risk. Intrusive results for MRS 11 yielded higher densities in grids that were closer to the NWP Bombardment Area. MD items, indicative of HE, were also recovered on the beach portions (Tamarindo Beach), which are popular tourist locations. Given the presence of MD a potential for human and ecological exposure to MEC in the northern portion of MRS 11 is high. Due to MD only being recovered in the northern portion, MEC risk for MRS 11 was evaluated as two separate areas (MRS 11 North and MRS 11 South).

1.3.1.6 MRS 13- Cayo Luis Pena Impact Area

During the post-award site visit, MD items [105 mm (HE and illumination); 5- and 3-inch projectiles; flares; and fuzes] were noted at 112 locations on MRS 13 (Figure 5-6). During the subsequent RI field work, multiple MD items were recovered on MRS 13 including a BDU-33, empty 5-inch illumination projectile and MD fragments. The potential for human exposure to MEC in MRS 13 exists due to the recreational users that frequent the beach areas.

1.3.2 MEC FS Recommendations

The data were collected in accordance with the approved RI Work Plan (WP) and were used to support a risk assessment approach as agreed upon by the TPP team. Two unexploded ordnance (UXO) items (Mk 25 Marine Flares) were recovered from MRS 09, these items are suspected to be from a non-DoD source. No other MEC items were recovered from the other five MRSs during the RI activities. Several MD items were located in MRSs 08, 09, 11, and 13. The MEC Hazard Assessment (MEC HA) noted that the potential for human receptors to come into contact with MEC at MRSs 08, 09, 11, and 13 exists. Based on the data collected by the RI, MRSs 06 and 10 have a low likelihood of containing an explosive hazard but the possibility cannot be completely ruled out. Therefore, a FS is recommended for all six Culebra Island MRSs to assess response action alternatives for managing risk associated with potential human interaction with MEC.

1.3.3 MC Risk Assessment

The baseline MC risk assessment followed a phased approach starting with simple screening level risk assessment (SLRA) and moving toward a more complex, site-specific deterministic risk assessment to evaluate the magnitude of the risk at the site. The results of the risk assessment aid in the development, evaluation, and selection of appropriate response alternatives.

Chapter 5 provides details for MC Characterization actives conducted for the RI. Chapter 7 provides the Baseline Risk Assessment for MC. The following paragraphs summarize the MC characterization results of the RI for each MRS.

1.3.3.1 MRS 06 - Artillery Firing Area

There are no exceedances of Human Health screening values, and therefore no unacceptable risks from former munitions use are present to human health from exposure to surface soil at MRS 06.

Barium was detected in soil at concentrations greater than the ecological screening value. MRS 06 is historically documented as a firing point. No munitions with barium as a major constituent were fired at targets located within MRS 06. It is likely munitions with barium were fired from MRS 06 towards MRS 08 and/or MRS 02; however, there is no evidence of concentrated munitions which would indicate a target area within MRS 06. During RI soil sampling, a bulldozed berm of trash and construction debris was discovered adjacent to the area where sampling was conducted. Since the debris found on site does not correlate with former activities at this MRS, the debris could be a remnant of the nearby trash pile. Therefore, barium is not considered to be related to former munitions use at MRS 06.

No unacceptable hazard or risk attributable to former munitions use is expected to occur at MRS 06 due to exposure to groundwater.

1.3.3.2 MRS 08 - Cayo Norte Impact Area

There were no exceedances in MC in the soil samples collected in MRS 08. Therefore no unacceptable human health or ecological risks related to MC are expected from exposure to surface soil in MRS 08.

1.3.3.3 MRS 09 - Soldado Point Mortar and Bombing Area

There are no exceedances of Human Health screening values, and therefore no unacceptable risks are present to human health from exposure to surface soil, surface water or sediment at MRS 09.

At MRS 09, unacceptable ecological risks are not expected for soil or surface water; however, aluminum and copper were detected in sediment at a concentration greater than the ecological screening value. The naturally occurring concentration of aluminum and copper in the *Rs* (Rock Land Group) soil type is high and sediment at MRS 09 was sampled in a collection lagoon that does not have an outfall or discharge in any way to other surface water bodies. Thus, it is likely that metals can be concentrated in the collection lagoon due to erosion from surrounding soils. During RI sampling activities, illegally dumped trash and metallic debris were observed in sediment at this site. Therefore, elevated concentrations of aluminum and copper in sediment may be a result of illegal dumping and concentration of metals in sediment, and may not be related to former munitions use at MRS 09. Thus, based on the results of sampling conducted at this site and evaluation of the surrounding area, aluminum and copper are not considered to be related to former munitions use at MRS 06..

No unacceptable hazard or risk attributable to former munitions use is expected to occur at MRS 09 due to exposure to groundwater.

1.3.3.4 MRS 10 - Defensive Firing Area No. 1

Environmental samples were not collected in MRS 10 since no MD was discovered during the RI field work. Given the lack of MD, and no evidence of concentrated munitions use, it is

reasonable to state that there are no human health and ecological risks related to former munitions use at MRS 10.

1.3.3.5 MRS 11 - Defensive Firing Area No. 2

There are no exceedances of human health screening values, and therefore no unacceptable risks to human health related to former munitions use are present from exposure to surface soil, surface water or sediment at MRS 11.

At MRS 11, mercury was detected in soil at a concentration greater than the ecological screening value. Due to the small quantities of MD and no MEC found in this MRS, it is unlikely that the mercury exceedance is a result of former munitions use. Mercury is used as a primary explosive (mercury fulminate) in very small quantities and is completely consumed in a detonation. Due to no MEC and very small quantities of MD, it is unlikely the source is from DoD use of the MRS. A municipal landfill is located on the northern portion of MRS 11 in close proximity to the area where mercury was detected above the ecological screening value. The landfill is unlined and contains items such as fluorescent light bulbs, appliances, and electronics. It is possible landfill leachate transported by overland flow is the suspected source that contributed to the mercury detected in soil at this site. Therefore, mercury in soil is not considered to be related to former DoD munitions use at MRS 11.

1.3.3.6 No unacceptable hazard or risk attributable to former munitions use is expected to occur at MRS 11 due to exposure to groundwater.MRS 13 - Cayo Luis Pena Impact Area

There were no exceedances of MC screening values in the soil samples collected in MRS 13. Therefore, no unacceptable human health and ecological risks related to former munitions use are expected in MRS 13.

1.3.4 Summary of Conclusions for MC

Based on results of the baseline risk assessment and a review of the MC risk assessment objectives, unacceptable human health risks are not expected at any of the Culebra Island MRSs investigated as part of this RI. No unacceptable ecological risks from former munitions use are expected at any of the Culebra Island MRSs investigated as part of this RI. Therefore MC will not be evaluated in the FS.

As noted above, the conclusions and recommendations of this report apply only to the terrestrial portions of the six MRSs addressed in the RI.

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CHAPTER 2. INTRODUCTION

2.1 PURPOSE

The primary purpose and scope of this project is to perform a RI designed to gather the data necessary to determine the nature and extent of MEC and MC contamination on six of the 14 MRSs identified on Culebra Island (MRSs 06, 08, 09, 10, 11, and 13). The data will be used to assess hazards that are associated with MEC and to conduct a baseline risk assessment for human health and the environment. . The results of the RI will be used to develop and evaluate alternatives in the FS. This RI report addresses the terrestrial portions of the MRSs only. The RI and FS for the underwater portions of these MRSs will be evaluated in separate documents. The remaining MRSs will be addressed under separate contracts. The conclusions and recommendations of this report apply only to the terrestrial portions of the six MRSs addressed in the RI.

2.2 PROPERTY DESCRIPTION AND PROBLEM

2.2.1 Location

The project location is Culebra Island (MRS 06, 09, 10, and 11), approximately 17 miles east of the main island of Puerto Rico and also includes surrounding islands Cayo Luis Pena (MRS 13), located approximately three-quarters of a mile off the western coast of Culebra Island and Cayo Norte (MRS 08), located approximately one-half mile off the northeast coast of Culebra Island. Culebra Island and the surrounding cays are part of the Commonwealth of Puerto Rico. This RI addresses the terrestrial portions of the six MRSs only. The underwater portion of the MRSs are not evaluated in this document. The site location is shown in Figure 1-1. MRS locations are shown on Figure 1-2. Figure 1-3, Plate 2 from the Archives Search Report, shows historical areas of DoD activity.

2.2.1.1 MRS 06 – Artillery Firing Area

MRS 06 is on the eastern end of Culebra extending from a point at the most northern tip of Mosquito Bay, northeast to a point just west of Duck Point, and east to the end of the island. This area consists of 826 land based acres and was used by the Marines for artillery firing points for exercises conducted from 1922 through the 1940s. (USACE, 2005a). Exercises involving small arms, 75 mm pack howitzers, 3-inch Stokes mortars, and 37 mm HE projectiles were conducted in Mosquito Bay in 1936. Beginning in 1936, the Marines fired 75mm projectiles from a firing point inland of Mangrove Bay at Weather Channel near Culebrita. Additionally, in 1937, U.S. Fleet Landing Exercise (FLEX) No. 4 involved use of the lagoon area at the back of Mosquito Bay. In 1939, the Marines fired from 1,000 yards northeast of Mosquito Bay toward the cays to the east. From Mosquito Bay, 37mm projectiles were fired west to water targets between Point Vaca and Snapper Shoal. (USACE, 2004). Currently, this MRS is almost entirely privately owned with residences scattered throughout. The water line is owned by the Puerto Rico Department of Natural and Environmental Resources (DNER) and the US Fish and Wildlife Service (USFWS). There is no barrier to public access. (CRIM, 2011)

2.2.1.2 MRS 08 – Cayo Norte Impact Area

MRS 08 includes only Cayo Norte and covers approximately 306 acres of land. Cayo Norte was leased by the Marines for training; however, it has not been determined from records whether the site was ever used for training (USACE, 2005a). Underwater portions of this MRS are not evaluated in this document.The property was leased from a private owner in 1924 for erecting artillery targets for 75 mm artillery practice. This lease was ended as part of the agreement between the Navy and the Mayor of Culebra in 1971. Notes on FLEX No. 5 indicate that impact of Cayo Norte was planned but that difficulties clearing people and cows from the island kept it from being used for an impact area. The surrounding waters to the east of the Cayo Norte may contain suspected 5-inch high velocity aircraft rocket (HVAR) from adjacent MRSs. No UXO has previously been documented as found on Cayo Norte. (USACE, 2005b). Cayo Norte is privately owned. (CRIM, 2011).

2.2.1.3 MRS 09 – Soldado Point Mortar and Bombing Area

MRS 09 consists of 328 acres (203 land acres, 125 water acres) on the very southern tip of the southern peninsula of Culebra. Underwater portions of this MRS are being evaluated in a separate document. Several training exercises including mortar firing, aerial bombing, and strafing were conducted on Soldado Point and the bay northwest of Soldado Point during the 1930s and 1940s (USACE, 2005a). The Supplemental Archives Search Report (ASR) mentions that 30- and 1,000-pound bombs were dropped in this area (USACE 2005b). Munitions used in the bay included 30-pound fragmentation bombs, 100-pound demolition bombs, 81mm mortars, and small arms.

This piece of property was accepted in a quitclaim deed from the Secretary of the Interior by the Governor of Puerto Rico in 1982. This property is managed by the DNER; however, several shacks have been built along the water at Sueno Cove (CRIM, 2011).

2.2.1.4 MRS 10 – Defensive Firing Area No. 1

MRS 10 consists of 547 acres (522 land acres, 25 water acres) on the southern peninsula of Culebra, south of the town of Dewey and north of MRS 09 (USACE, 2005a). Underwater portions of this MRS are not evaluated in this document. Marines conducted amphibious landing and ground maneuver training using 81mm mortars on the beaches and hills in this area from the 1920s through the 1940s. Specifically, the hill on the north end of the MRS has been listed as a 1935 area of direct fire from 3" Common projectiles, and Snug Bay was shown as a 1935 water area for direct fire. Additionally a 1924 outpost and ammunition storage area is located on the north end of the MRS near Snug Bay (USACE, 2005b). MRS 10 has many residents and businesses. Most of the development is near the town of Dewey on the north end of the site; however, houses are scattered throughout the southeastern side of this MRS. This MRS is almost entirely privately owned except for municipality lands such as the police and fire stations. (CRIM, 2011).

2.2.1.5 MRS 11 – Defensive Firing Area No. 2

MRS 11 is located on the west side of Culebra between the NWP and the town of Dewey. The area is approximately 719 acres (694 land acres, 25 water acres) (USACE 2005a), and most of the southern portion of this MRS has been extensively developed for residential use. Underwater

portions of this MRS are not evaluated in this document. The areas along the beach and the west side of this site are less developed. The land is privately owned with some municipality properties such as the school, hospital, and government buildings (CRIM, 2011). Several training exercises were conducted in this area, including 75mm and 155mm firing from Firewood Bay at Mono Cay and portions of Cayo de Luis Pena in 1924; FLEX No. 4 with firing of small arms and 81mm mortars in 1936; and FLEX No. 7 in 1941 with boat-to-beach firing of 5-inch and 6-inch projectiles. (USACE, 2005b)

2.2.1.6 MRS 13 – Cayo Luis Pena Impact Area

MRS 13, Cayo de Luis Pena, with 484 acres of land and 864 total MRS acres (484 land acres, 380 water acres), is approximately three quarters of a mile off the western coast of Culebra. (USACE, 2005a). Underwater portions of this MRS are being evaluated under a separate document. The northern tip of this island was used as a firing target during Marine exercises conducted between 1924 and 1941. Records show that 75mm projectiles were fired at the Cayo in 1924 and that 155mm, 37mm, 8-inch, and 6-inch projectiles may have also been used. In the 1960s, an observation point was erected on the hilltop on Luis Pena, including a run-in line, helipad, and living quarters. Cayo de Luis Pena is managed by the USFWS as part of the Culebra National Wildlife Refuge.

Note: In MRS 11 and 13 (overshoot zones from the Northwest Peninsula target area), there is evidence of Navy illumination rounds (cases), however these don't contain Explosive D filler. Based on data collected under other efforts and source information (2007 SI, ASRs), the target area for naval munitions is located on the Northwest Peninsula (MRS 02).

2.2.2 Topography

Culebra Island and the surrounding cays are comprised of sandy beaches, irregular rugged coastlines, lagoons, coastal wetlands, steep mountains, and narrow valleys. Ninety percent of the island is mountainous. The island contains an east-west trending ridge with an average elevation of 300 feet mean sea level (msl) in the northern part of the island. The highest point on Culebra is Mount Resaca at approximately 640 feet msl. Topographic features are shown on Figure 1-2.

Two Culebra Cayos are included in this RI. Cayo Norte (MRS 08) is a generally flat island with several hills on the western side. The elevation ranges from 80 to 300 feet msl. The shoreline on the north side of the island consists of cliffs dropping off to the water. The southern side slopes down to the water and contains beaches. The island consists of light to moderate vegetation with large open areas. There is one body of water on the south side of the island that is connected to the beach; it is most likely a large, brackish tidal pool.

Cayo Luis Pena (MRS 13) is comprised of sandy beaches, irregular rugged coastlines and steep mountains. A peak of 476 feet msl is located in the center of the Cayo and a smaller peak of 171 feet msl exists on the northern peninsula of the Cayo.

2.2.3 Climate

The weather on Culebra Island is generally warm year round due to its tropical marine climate. Based on the Charlotte Amalie HAR, Virgin Islands, weather station (1972 - 2012) located 20 miles to the east, yearly average rainfall is approximately 40.01 inches. The months of August through November are considered the wet season, and the driest months are January through

April. Average daily temperatures range from an average maximum of 87.4 °F and an average low of 75.3°F. Winds are generally from the east-northeast during November through January and from the east during February through October. Yearly average wind speed is 8 knots. Hurricane season is from June through November, and severe hurricanes hit Culebra every 10 to 20 years. The average rainfall is provided in Table 2-1 (SERCC, 2012).

Table 2-1: Average Rainfall, Culebra Island Puerto Rico

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
inches	**2.03**	**1.45**	**1.46**	**2.74**	**3.35**	**2.75**	**2.66**	**3.83**	**5.42**	**5.94**	**5.54**	**2.84**	**40.01**

Source: SERCC, 2012

2.2.4 Vegetation

Vegetation is moderately to extremely dense on undeveloped portions of Culebra, Luis Pena, Northeast Cay, and Culebrita; however, vegetation is sparse or absent on many of the smaller cays as most are rocky with very little soil. Hazardous vegetation includes the Mesquite acacia or thorny brush, which may be present on Culebra and all of the surrounding cays, and the poisonous Manchineel tree (also called Manzanillo Tree or "Tree of Death"), which is known to be present on the NWP and near Flamenco Lagoon. Endangered vegetation includes the spineless Culebra Island cactus (*Leptocereus grantianus*).

2.2.5 Geology

Culebra Island and the surrounding cays are part of the Culebra Archipelago. Culebra is underlain mainly by mixed volcanic rocks which include lava, tuff, breccia, and tuffaceous breccia. Bedrock is exposed at land surface in 50 to 70 percent of the Island and a thin granulated soil (0.3 to 0.6 m thick) occurs in pockets between rocky areas (USGS, 2002). Some small areas underlain by alluvium near the coast. The clastic sediments are present in small areas along the coast and within the small valleys incised by the intermittent streams (USGS, 1996). The rocks in the north-central portion of Culebra and on the east side of Cayo Luis Pena contain diorite porphyry inclusions and have little to no porosity due to compaction and quartz and calcite growth in the pore space (USACE, 1995).

2.2.6 Hydrology

There are no permanently flowing surface water streams on Culebra; potable water is obtained from Autoridad de Acueductos y Alcantarillados (AAA), a Commonwealth-owned utility that maintains a pipeline from the main island routed through the neighboring island of Vieques. Three large ephemeral streams drain the hills north of Great Harbor to the south, and one large ephemeral stream has developed along an old, washed-out jeep road on the north side of the island toward Brava Beach. These ephemeral streams generally carry water only after heavy precipitation. There are many small ephemeral gullies and ditches throughout the island, and several lagoons are present on Culebra as well (USGS, 1948).

The following sections describe the hydrology within each MRS.

2.2.6.1 MRS 06 – Artillery Firing Area

The heavily dissected terrain and moderate elevations ranging from sea level to over 225 ft msl, leads to multidirectional surface water flow patterns. The central portion of the MRS primarily drains in a temporal stream to Mangrove Bay to the southeast, the northeastern portion of the MRS primarily drains northeast between Duck Point and Larga Beach. A ridgeline keeps surface water draining from this MRS from draining into Zoni Lagoon. The central areas of the MRS drain into Mosquito Bay. No significant volumes of fresh surface water are present within the MRS. Several small lagoons are scattered throughout the MRS.

2.2.6.2 MRS 08 – Cayo Norte Impact Area

Surface water on the island of Cayo Norte primarily drains in ephemeral streams radially into the ocean. Two intermittent streams drain the south facing slopes of the MRS into a lagoon located in the southcentral area of the MRS.

2.2.6.3 MRS 09 – Soldado Point Mortar and Bombing Area

Surface water in MRS 09 drains radially from elevations that rise to over 225 ft. One ephemeral stream drains into Ensenada Dakity. Two lagoons are present within the MRS, one due west of Ensenada Dakity, the other north west of Sueno Cove. The areas to the northwest drain into Ensenada Fulladosa. The north eastern areas either drain directly into Ensenada Honda, or into the lagoon west of Ensenada Dakity, which eventually flows either into Ensenada Honda or directly into the Atlantic Ocean. The Southeastern portion of the site drains into Sueno Cove. The Southwestern areas drain directly into the ocean.

2.2.6.4 MRS 10 – Defensive Firing Area No. 1

Surface water in MRS 10 drains in small ephemeral gullies radially from a central peak which rises to over 325 feet. Surface water draining from the northern areas of the MRS drain directly into Ensenada Honda, and the northeastern areas drain into Ensenada Fulladosa. The northwestern areas drain into a small inlet to the northwest of the MRS that is hydrologically connected to both Ensenada Honda to the east and Bahia De Sardinas to the west. No perennial surface water bodies are present.

2.2.6.5 MRS 11 – Defensive Firing Area No. 2

Surface water flow in MRS 11 is divided by a northwest/southeast trending ridgeline which rises to over 400 feet. Water in the northern areas drain into Flamenco Lagoon. The eastern side of the ridge drains to an ephemeral stream and eventually flows into Ensenada Honda. The western side of the ridge either drains to Cornello Lagoon located on the central western side, or to Canal Luis Pena. The northern areas of the western side drain to Tamarindo Bay.

2.2.6.6 MRS 13 – Cayo Luis Pena Impact Area

Surface water in MRS 13 drains radially in small ephemeral gullies from a central peak which rises to over 450 ft. in the northern areas and from a smaller peak rising to approximately 150 ft. in the southeastern areas. The northern portions of the smaller peak flow to a small unnamed lagoon. No significant volumes of fresh surface water are present within the MRS. A lagoon

present on the northern edge of the southern lobe of the island is heavily influenced by tidal water.

2.2.7 Hydrogeology

Ground water in Culebra occurs in alluvial deposits and in the volcanic and plutonic rocks. Alluvial deposits are located along major stream valleys that reach the coast. The alluvium is mostly composed of silt and clay with limited quantities of sand and gravel. Fractures and joints within the volcanic and plutonic rock formations store water in small quantities. Most of these fractures and joints diminish in number and size with depth and pinch out at about 300 feet below land surface. Water-table conditions prevail in the bedrock aquifer (USGS, 2002).

By comparing changes in water levels with records of well pumpage and estimates of recharge, the specific yield for the bedrock aquifer was estimated as less than one percent (USGS, 1996).

The majority of depths to groundwater range from 0 to 15 feet near the shore line where most people are located, increasing as elevation rises to a maximum recorded value of 48 feet at higher elevations (USGS, 1995). The wells sampled in the RI reported depth to groundwater findings of 3.5 to 10.5 feet bgs in MRS 06, 21.4 ft bgs in MRS 09, and 18.3 feet bgs in MRS 11.

Historically, desalinated seawater and rooftop-rainfall catchments have served as primary sources for water supply. The Puerto Rico Aqueduct and Sewer Authority (PRASA) is responsible for freshwater supply and distribution to the public for the island. In the past, PRASA maintained a municipal well field of five wells as a major source of water for public supply. In 1971, a desalination plant was built to purify the well water which has a high mineral content and is unsuitable for drinking (USGS, 1995). Eventually, the wells could not meet demand and currently water demands are met by water pumped in from Puerto Rico mainland. There are no indications that this will change in the future.

2.2.8 Sensitive Environments

The information identifying sensitive environments on Culebra was identified in a 2011 biological inventory found in Appendix P (Gaddy, 2011). Table 2-2 lists all endangered, threatened, and otherwise protected species known to occur or potentially-occur on the island of Culebra and outlying cays. Species historically known to occur on Culebra and outlying cays are given in bold type. Species not listed in bold type are federally-listed species known to occur on Vieques, St. Thomas, or St. Croix that potentially-occur on Culebra and outlying cays.

Eighteen of the twenty-three species in Table 1 are federally-listed as endangered or threatened by the U. S. Fish and Wildlife Service (USFWS, 2010b and USFWS, 2012c), four species are officially listed by the Puerto Rico Department of Natural Resources (Estado Libre Asociado de Puerto Rico). Departmento de Recursos Naturales y Ambientales, 2004), and one species (*Justicia culebritae*) is listed as a federal "species of concern."

Of the twenty-three species in Table 1, only four species—*Dermochelys coriacea* (leatherback turtle), *Eretmochelys imbricata* (hawksbill turtle), *Leptocereus grantii* (Grant's leptocereus), and *Justicia culebritae* (Culebrita water-willow)—are known to occur within the six MRS study areas. The leatherback turtle is known to be found in MRS 6 and MRS 8; the hawksbill turtle is known to be found in MRS 8 and MRS 09; Grant's leptocereus is known to be found in MRS 9, 10, and 11; and the Culebrita water-willow is known to be found in MRS 8 and MRS 13. All of

the above species are federally-listed as "endangered" with the exception of the Culebrita water-willow, which is listed as a federal "species of concern."

According to the DNER, the conservation priority areas for Culebra and associated cays are as follows:

- All of the lagoons on Culebra
- Monte Resaca
- All beaches around Culebra
- The designated critical habitat area for the Virgin Islands Boa
- Flamenco Peninsula
- Puerto del Manglar
- Los Canos
- Punta Soldado
- Bahia (also called "Ensenada") Cementerio
- All cayos and cays around Culebra
- The Culebra National Wildlife Refuge
- The Canal Luis Pena Natural Reserve.

The USACE document Standard Operating Procedures for Endangered Species Conservation and their Habitat on DERP-FUDS Project No. I02PR006802.Culebra, Puerto Rico (included as Appendix M of the RI Work Plan) provided a series of SOPs to avoid or minimize impacts to threatened and endangered species during Defense Environmental Restoration Program (DERP)-FUDS work at locations on Culebra Island and adjacent cays and in surrounding waters that serve as habitat for these species. These SOPs "are in accordance with on-going communication with staff from the USFWS, the National Marine Fisheries Service (NMFS) and the DNER, as well as pursuant to the Interim Guidelines provided by FWS to work on lands of Culebra National Wildlife Refuge, with the U.S. Army Corps of Engineers (USACE) Regulations and Environmental Operating Principles". USA field teams followed all recommended procedures to minimize impacts during the RI field work. The field biologist marked each endangered plant with ribbon to avoid disturbance.

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939 **Table 2-2: Known and potentially occurring federally- and Puerto Rican- listed**
940 **endangered, threatened, and otherwise protected species on the island of Culebra and**
941 **outlying Cays, Puerto Rico.**

Species	Common Name	Taxonomic Group	Status	Habitat
Anolis roosevelti	**Culebra Giant Anole; Lagartijo Gigante de Culebra**	**Lizard**	**FE/CR**	**Mature Forest**
Calyptranthes thomasina	Thomas' Lidflower	Tree-*Myrtaceae*	FE/CR	Forest (Vieques)
Caretta caretta	**Loggerhead Turtle**	**Turtle (Marine)**	**FT**	**Beaches**
Catesbaea melanocarpa	Tropical Lilythorn	Shrub-*Rubiaceae*	FE	Shrub Forest on Limestone (St. Croix)
Chamaecrista glandulosa var. mirabilis	Jamaican Broom	Tree-*Fabaceae*	FE/EN	Forest (Vieques)
Charadrius melodus	**Piping Plover**	**Bird**	**FE/CR**	**Beaches**
Chelonia mydas	**Green Turtle**	**Turtle (Marine)**	**FT/EN**	**Beaches**
Dendrocyna arborea	**West Indian Whistling Duck**	**Bird**	**CR**	**Wetlands**
Dermochelys coriacea	**Leatherback Turtle**	**Turtle (Marine)**	**FE/EN**	**Beaches**
Epicrates monensis grantii	**Virgin Island Tree Boa; Boa Pinta**	Snake	FE/CR	Forest with continuous canopy and abundance of anoles
Eretmochelys imbricata	**Hawksbill Turtle**	**Turtle (Marine)**	**FE/EN**	**Beaches**
Goetzea elegans	Beautiful Goetzea	Tree/Shrub-*Solanaceae*	FE/EN	Forest (Vieques)
Justicia culebritae	**Culebrita Island Water-Willow**	**Subshrub-*Acanthaceae***	**SC**	**Coastal Scrub/Shrub**
Leptocereus grantianus	**Grant's leptocereus**	**Herb-*Cactaceae***	**FE/CR**	**Nonforest and Forest**
Mabuya mabouya sloanei	**Slipperyback Skink; Lucia; St. Lucia**	**Lizard**	**VU**	**Forest**
Pelecanus occidentalis	**Brown Pelican**	**Bird**	**FE/EN**	**Bays and Coastal Areas**
Peperomia wheeleri	**Wheeler's Peperomia**	**Herb-*Piperaceae***	**FE/EN**	**Forest**
Stahlia monosperma*	**Cobana Negra**	**Tree-*Fabaceae***	**FE/VU**	**Margins of Mangrove Swamps**
Sterna antillarum	**Least Tern**	**Bird**	**FE/DD**	**Beaches**
Sterna dougallii	**Roseate Tern**	**Bird**	**FE/VU**	**Nonforested Areas**

Species	Common Name	Taxonomic Group	Status	Habitat
Trachemys stejnegeri	**Jicotea; P. R. Slider**	**Turtle**	**DD**	**Wetlands**
Typhlops granti	**Culebra ciega de Grant; Grant's Blind Worm Snake**	**Snake**	**DD**	**Forest**
Zanthoxylum thomasianum	St. Thomas Prickly-Ash	Shrub-*Rutaceae*	FE/EN	Evergreen Forest on Limestone (St. Thomas)

Source: Compiled by Gaddy, 2011 based on USFWS, 2010b and c

Bold Type-indicates that the species is known to occur on Culebra.

Federal Listings:

FE-federally-listed as endangered;
FT-federally-listed as threatened; **SC**-not officially list, but "species of concern," according to Fish and Wildlife Service;

Puerto Rican Listings:

VU-vulnerable;
EN-en peligro;
CR-en peligro critico;
DD-deficiencia de datos.

*Known to be planted on Culebra; may have escaped into wild areas.

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956 **Table 2-3: Study Areas, habitat/cover types, and endangered species.**

Study Area	Name	Habitat/Cover Types	Listed Speciespresent Or Potentially Present *
MRS 06	Artillery Firing Area (Viento Point Area)	Beaches/Shores; Lagoons; Rocky Cliffs; Legume Canopy/Grassland Understory; Low Legume Shrub-Scrub/Cactus	*Dermochelys coriacea* (leatherback turtle)*;* *Eretmochelys imbricata* (hawksbill turtle)*;* *Epicrates monensis grantii* (Virgin Islands tree boa)*;* *Leptocereus grantii* (Grant's leptocereus)
MRS 08	Cayo Norte Impact Area	Beaches/Shores; Lagoons; Rocky Cliffs; Open Grassland; Closed Forest Canopy; Legume Canopy/Grassland Understory	*Dermochelys coriacea* (leatherback turtle)*;* *Eretmochelys imbricata* (hawksbill turtle)*;* *Epicrates monensis grantii* (Virgin Islands tree boa)*;* *Anolis roosevelti* (Culebra giant anole)*;* *Justicia culebritae* (Culebrita water-willow)
MRS 09	Soldado Point Mortar and Bombing Area	Beaches/Shores; Lagoons; Rocky Cliffs; Low Legume Shrub-Scrub/Cactus	*Eretmochelys imbricata* (hawksbill turtle)*;* *Leptocereus grantii* (Grant's leptocereus)
MRS 10	Defensive Firing Area No. 1 (southeast of Dewey)	Beaches/Shores; Rocky Cliffs; Open Grassland; Closed Forest Canopy; Legume Canopy/Grassland Understory; Low Legume Shrub-Scrub/Cactus	*Eretmochelys imbricata* (hawksbill turtle)*;* *Epicrates monensis grantii* (Virgin Islands tree boa)*;* *Anolis roosevelti* (Culebra giant anole)*;* *Leptocereus grantii* (Grant's leptocereus)*;* *Peperomia wheeleri* (Wheeler's peperomia)
MRS 11	Defensive Firing Area No. 2 (northwest of Dewey)	Beaches/Shores; Lagoons; Rocky Cliffs; Open Grassland; Closed Forest Canopy; Legume Canopy/Grassland Understory	*Eretmochelys imbricata* (hawksbill turtle)*;* *Epicrates monensis grantii* (Virgin Islands tree boa)*;* *Anolis roosevelti* (Culebra giant anole)*;* *Leptocereus grantii* (Grant's leptocereus)*;* *Peperomia wheeleri* (Wheeler's peperomia)
MRS 13	Cayo Luis Pena Impact Area	Beaches/Shores; Lagoons; Rocky Cliffs; Closed Forest Canopy	*Dermochelys coriacea* (leatherback turtle)*;* *Eretmochelys imbricate* (hawksbill turtle)*;* *Epicrates monensis grantii* (Virgin Islands tree boa)*;* *Anolis roosevelti* (Culebra giant anole)*;* *Justicia culebritae* (Culebrita water-willow)*;* *Leptocereus grantii* (Grant's leptocereus)*;* *Peperomia wheeleri* (Wheeler's peperomia).

957 *See Table 1 for species details.
958 **Source: Biological Study**

2.2.9 Cultural and Archeological Resources

According to the National Register Information System (NRIS), National Historic Landmarks (NHL) list, National Heritage Areas (NHA) list, and National Park Service (NPS), there are no registered cultural resources within the Culebra Island MRSs. According to the Puerto Rico State Historic Preservation Office (SHPO), there are no known architectural resources within the boundary of the MRSs area; however, an architectural survey has not yet been conducted for Culebra.

2.2.10 Demographics

The U.S. Census Bureau's (USCB) Census 2010 provided the general demographics of the Municipality of Culebra summarized in Table 2-4 (USCB, 2011).

Table 2-4: Demographic Summary -- Municipality of Culebra, Puerto Rico

General Characteristics	Number	Percent
Total Population	1,818	
Male	921	50.7
Female	897	49.3
Population Density (persons per square mile)	69.6	
Median Age (years)	39.4	
Under 5 Years	101	5.6
18 Years and Over	1,403	77.2
65 Years and Over	265	14.6
Total Housing Units	1,603	
Occupied Housing Units	749	46.7
Owner-Occupied Housing Units	484	64.6
Renter-Occupied Housing Units	265	35.4
Vacant Housing Units	854	53.3

2.2.11 Current and Future Land Use

2.2.11.1 MRS 06 Artillery Firing Area

MRS 06 is almost entirely privately owned except for the water line, which is owned by the DNER and USFWS. This tract contains several residences scattered throughout the MRS. Portions of this tract are currently being developed with others listed for sale for potential development. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility.

2.2.11.2 MRS 08 Cayo Norte Impact Area

MRS 08 covers all of Cayo Norte, a privately owned island with no barriers to access. One structure identified as a part time residence is present on the south slope (USACE, 1995). The Cayo is owned by an investment group with plans for development. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. (CRIM, 2011)

2.2.11.3 MRS 09 Soldado Point Mortar And Bombing Area

MRS 09 is managed by the DNER and residential development is not currently allowed on the site; however, several shacks and small structures are present in the southeastern portion of the MRS. Several structures are located in the northwestern portion of the MRS. The potential exists for public area structures to be developed at some point in the future. There are no restrictions for using the beach areas or entering the surrounding waters for recreation activities. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. Seasonal surf action could cause changes in the bottoms of the surrounding waters. (CRIM, 2011)

2.2.11.4 MRS 10 Defensive Firing Area No. 1

MRS 10 is almost entirely privately owned except for municipal lands such as the police and fire stations. Residences are concentrated toward the shoreline along the northern areas of the MRS, and scattered toward the in land in the south eastern areas. Some residential areas have been developed on the hills overlooking the potential mortar impact areas. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. Seasonal surf action could cause changes in the bottoms of the surrounding waters. The water area adjacent to this shore is generally not used for recreational activities. (CRIM, 2011)

2.2.11.5 MRS 11 Defensive Firing Area No. 2

Most of the southern portion of MRS 11 has been extensively developed for residential use. The areas along the beach and the west side of the MRS are less developed. The land is privately owned with some municipal properties which include a school, hospital, and government buildings. Residential areas have been developed on the hills overlooking the potential mortar impact areas. Development could occur throughout the site. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. The immediate offshore waters are part of the Luis Pena Water Refuge (CRIM, 2011).

Residences and other development are concentrated in the southeastern portion of the MRS. A few residences are located along the northern border. A municipal landfill, built in 1984 of approximately 13 acres is located in the northwestern portion of the MRS on the south facing slope. The island airport is located immediately north of the eastern end of the MRS.

2.2.11.6 MRS 13 Cayo Luis Pena Impact Areas

MRS 13 covers all of Cayo Luis Pena. The Cayo is managed by the USFWS and DNER as part of the Culebra National Wildlife Refuge. Residential areas do not exist on Cayo Luis Pena. USFWS personnel access various areas of the site often, as do boaters who often visit the beach. Heavy vegetation and steep terrain create barriers to access most of the upland areas. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development (public structures) that could reduce distances from the site to inhabited areas or otherwise increase accessibility (CRIM, 2011).

2.3 HISTORICAL INFORMATION

In 1898, the Spanish American War concluded and the Kingdom of Spain ceded all of Puerto Rico to include Culebra and its adjacent cays to the U.S. Shortly after, in 1900, President Theodore Roosevelt placed Culebra under the jurisdiction of the Department of the Navy. In 1903, the Navy acquired approximately 4,200 acres of land by transfer and purchase; further donations, transfers, and leases between 1939 and 1965 brought the total land acquired to approximately 4,800 acres. Although portions of the site were never formally acquired, military use included the entire Island of Culebra and all surrounding cays. The Navy retained 87.5 acres near Flamenco Point that are not eligible for FUDS. The NWP Target Area was also deemed ineligible for the FUDS program per Public Law 93-166 (Military Construction Authorization Act, 1974). The 2005 revised Findings and Determination of Eligibility report states that the site, except for 87.5 acres recently transferred from the control of the Navy and the 408 acres of the NWP (1982 Quit claim Deed), has been determined to be formerly used by the DoD (USACE, 2005).

Although reconnaissance trips, development of a base, and placement of guns began as early as 1902, the first maneuvers at Culebra did not begin until January 1914, with the Marines first Advance Base Expedition establishing several encampments and 3-inch and 5-inch gun batteries at the mouth of Great Harbor. The Marines' use of the island continued over several more decades. In 1922, an exercise was conducted firing 7-inch, 8-inch, 3-inch, 155-millimeter (mm), 75mm, and 37mm guns. In 1924, maneuvers included establishment of ammunitions dumps throughout the island, firing of 75mm and 155mm guns, and mine placement in several water areas around Culebra.

In 1934, the Navy and Marines organized to carry out the first FLEX, Fleet Problem XV. Weapons used during this exercise included .30-caliber machine guns, 3-inch anti-aircraft guns, 6-inch gun batteries, 75mm batteries, and 6-inch naval guns. Six more FLEXs were conducted on Culebra Island between 1935 and 1941. Photographic accounts document Marine landing exercises in 1946 and 1947. Marine training at Culebra is believed to have continued until the late 1950s.

The NWP was used for live gunnery practice between 1936 and January 1, 1972. During this period of time, a total of 750,000 naval rounds had been estimated as being fired. During the period 1942 to 1968, an estimated 320,000 units of air ordnance were fired at the NWP. Eighty percent of the ammunition was 5-inch caliber. Ten percent was comprised of 3-inch, 6-inch, and 8-inch gun ammunition. The balance included other varieties up to and including 16-inch mortars, and howitzers. (U.S. Navy Memorandum dated June 1973 from Commander in Chief

U.S. Atlantic Fleet to Chief of Naval Operations, Subject: Time-Phased Plan for Relocation of Training Activities from the Culebra Complex to the Islands of Desecheo and Monito). Naval exercises included aerial bombardment, submarine torpedo fire, and naval gunfire directed at NWP and many cays. All military use of the island was terminated in 1975. In summary, the Island of Culebra, nearby cays, and surrounding water were used between 1902 and 1975 for training and live fire of bombs, mortars, rockets, torpedoes, projectiles, and small arms.

In 1975, the Navy issued a report of excess for the land associated with the Navy's original 1900 holdings. Beginning in 1978, all of the land acquired by the military on Culebra and the surrounding cays were excessed to the Department of the Interior (DOI) or transferred to the government of Puerto Rico by quitclaim deed in 1983.

There is no historical or anecdotal evidence that Chemical Warfare Materiel (CWM) was ever used within the site.

2.4 PREVIOUS INVESTIGATIONS

2.4.1 1991 – Inventory Project Report (INPR), Culebra, Puerto Rico, Property No. I02PR0068, Original May 1991

The original INPR qualified 2,660 acres of Culebra as eligible for consideration under the DERP for FUDS. The INPR, signed on 24 December 1991, established the Culebra Island site as a FUDS, defined a site boundary, and assigned FUDS Project No. I02PR006800. The Findings and Determination of Eligibility (FDE) concluded that "the site, except for 87.5 acres still under control of the Navy, has been determined to be formerly used by the Department of Defense. It is therefore eligible for the Defense Environmental Restoration Program (DERP)." (USACE, 1991)

2.4.2 1995 – Archives Search Report, Findings, Ordnance and Explosive Waste, Culebra Island National Wildlife Refuge, Culebra, Puerto Rico, February 1995

The ASR presented the findings of an historical records search and site inspection for MEC presence in the Culebra Island National Wildlife Refuge. As part of the ASR, a site visit was conducted in October 1994, during which the team identified MD on Cayo Botella, Cayos Geniqui, and Cayo del Agua. In addition, MD was identified on Flamenco Beach, Flamenco Peninsula, and the hillside near Cerro Balcon. The ASR listed several ordnance items verified on site by either explosive ordnance disposal (EOD) personnel or the ASR field team. The ASR covered the entire land area of Culebra Island and the nearby keys, about 7,300 acres of land, and also included 85,200 acres of surrounding water. The report included site history, site descriptions, and real estate ownership information, and confirmed the presence of ordnance based on available records, interviews, and site inspections. (USACE, 1995)

2.4.3 2004 – Archives Search Report Supplement

In 2004, an ASR supplement was completed by the USACE Rock Island District as an addition to the 1995 ASR. The report provides details of aerial training conducted by the Navy between 1935 and 1975 and identifies the following range areas:

- Water West: Part of this area is included in MRS 12. A local diver reported underwater ordnance in this area. Suspect munitions include Mk II 6-inch HE projectiles.

- Water Center: This area is included in MRS 12. A local diver reported underwater ordnance in this area. Suspect munitions include Mk II 6-inch HE projectiles.
- Water South: This water area includes the small bay north of Soldado Point (part of MRS 09). A local diver reported underwater ordnance in this area. Suspect ordnance includes Mk II 6-inch HE; however, other ordnance types are suspected due to use as 1936 aerial target and 1938 mortar boat firing exercises.
- Rifle Range South: This small arms range is believed to be located on undeveloped land near the southern tip of the island in MRS 09. This range has not been confirmed. The 2005 Inventory Project Report, indicates strafing (.50 caliber) training was conducted in the area. (USACE, 2004a).

2.4.4 2005 – Inventory Project Report (INPR), Original May 1991, Revised July 2005 (Final)

The original INPR was revised in 2005, clarifying the military use of the Island of Culebra and divided the original site, Property No I02PR0068, into 14 separate MRSs. One hazardous and toxic waste (HTW) project was identified and assigned the number 00, and 13 MMRP project areas were identified and assigned Risk Assessment Code (RAC) scores. MRS 01 was not defined (USACE, 2005a).

The following MMRP projects and RAC scores were listed:

- MRS 02 – Culebra and Cays, RAC 1
- MRS 03 – Flamenco Bay Water Area, RAC 1
- MRS 04 – Flamenco Lagoon Maneuver Area, RAC 1
- MRS 05 – Mortar and Combat Range Area, RAC 1
- MRS 06 – Artillery Firing Area, RAC 3
- MRS 07 – Culebrita Artillery Impact Area, RAC 1
- MRS 08 – Cayo Norte Impact Area, RAC 3
- MRS 09 – Soldado Point Mortar and Bombing Area, RAC 2
- MRS 10 – Defensive Firing Area No. 1, RAC 2
- MRS 11 – Defensive Firing Area No. 2, RAC 1
- MRS 12 – Luis Pena Channel Water Areas, RAC 1
- MRS 13 – Cayo Luis Pena Impact Area, RAC 1
- MRS 14 – Airfield and Camp Area, RAC 3

The HTW Project 00, also as known as The Former Lower Camp Debris Site, encompasses a 40,000-square foot section (100 feet by 400 feet) of marine wetland located along the eastern shoreline of Ensenada del Cementerio (Figure 1-2). The surface and groundwater drains directly into Ensenada Honda and does not directly affect the MRSs covered by this project. 2005 – Supplemental Archives Search Report, Culebra, Puerto Rico, September 2005

USACE St. Louis District prepared the Supplemental ASR in 2005 as an addition to the 1995 ASR. The Supplemental ASR is the source of most of the historical information pertaining to site operations and identified the key areas of focus for the subsequent SI. This document provided a

detailed summary of military activities conducted on Culebra Island and the surrounding cays. The document summarized planned and/or executed maneuvers and training conducted at the site, including specific time periods, locations, and munitions used. (USACE, 2005b)

2.4.5 2007-Site Inspection Report, Culebra Island Site, Puerto Rico, FUDS Project No. I02PR006802 through 14, 2007

Parsons Infrastructure and Technology Group (Parsons) completed a site inspection of the Island and published a Final SI Report in September 2007. The fieldwork included approximately 50 miles of Qualitative Reconnaissance, and the collection of 27 soil and five sediment samples. The fully validated samples were analyzed for MC metals and explosive compounds. Three of the soil samples were collected to serve as ambient data.

Parsons concluded that the potential for MEC to pose a human health risk existed within 12 of the 13 MRSs, but that there was no evidence to indicate that MRS 14 had potential MEC contamination. Parsons further concluded that although there was potential for MEC to pose a risk at the Culebra Island sites, since the field team did not identify an imminent threat to the public, a Time-Critical Removal Action (TCRA) was not necessary. However, due to the presence of MD and MEC at several areas within the site, Parsons recommended these sites proceed to the RI/FS. (Parsons, 2007)

The list of constituents for munitions known or suspected was developed in the SI and is included in Appendix X of this report.

There is no evidence the lagoons of the island were used for target practice.

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CHAPTER 3. PROJECT REMEDIAL RESPONSE OBJECTIVES

This RI project was conducted in accordance with the objectives and goals established by stakeholders during TPP as summarized in the Final TPP Memorandum (Appendix E). The primary objective for the Culebra Island MRSs was to determine the nature and extent of MEC and MC. The TPP team agreed that the RI data collection would focus on geophysical (transects and grids) and intrusive investigation of grids in the upland areas, analog intrusive investigations along accessible beaches and in-use trails on MRS 13, and collection of environmental samples at locations in and around areas that represent the highest likelihood for MC contamination i.e., where MEC or MD is present, at demolition sites, and where there is evidence of low order detonations.

3.1 CONCEPTUAL SITE MODEL AND PROJECT APPROACH

Conceptual Site Models (CSMs) can help identify risks to human health and the environment by identifying complete exposure pathways between physical media affected by site-related contamination and potential human or ecological receptors. During the SI at Culebra (Parsons, 2007), the site was evaluated as 14 MRSs. The evaluation of potential MEC exposure concluded that, based on the limited scope of the SI, the MEC exposure pathway was potentially complete for all six MRSs evaluated during this RI. The MRS boundaries, which were based on former suspected military use and current land use, provided the basis for the pre-RI CSM presented in the Final TPP Memo (Appendix E) and RI WP. Based on the results of the SI, the pre-RI CSM identified a potentially complete MEC exposure pathway for human receptors in MRSs 06, 08, 09, 10, 11, and 13. Pre-RI Conceptual Site Model (CSM) Diagrams are provided as Figures 3-1 through 3-6. The objective of the RI field activities was to adequately characterize each area for the purpose of evaluating and developing effective remedial alternatives. Digital geophysical mapping, intrusive investigation of anomalies, analog mag-and-dig investigations, and MC sampling were the basis of the RI characterization. In addition to collecting samples at specified locations in some MRSs, MC sampling would also be done in association with MEC and MD with residual explosives. One consequence could be that some MRSs would not have MC samples collected. The following sections provide additional details regarding the CSM and project approach for each MRS. Based on the results of the contaminant characterization conducted as part of this RI, a revised CSM is presented and discussed in Chapter 5.

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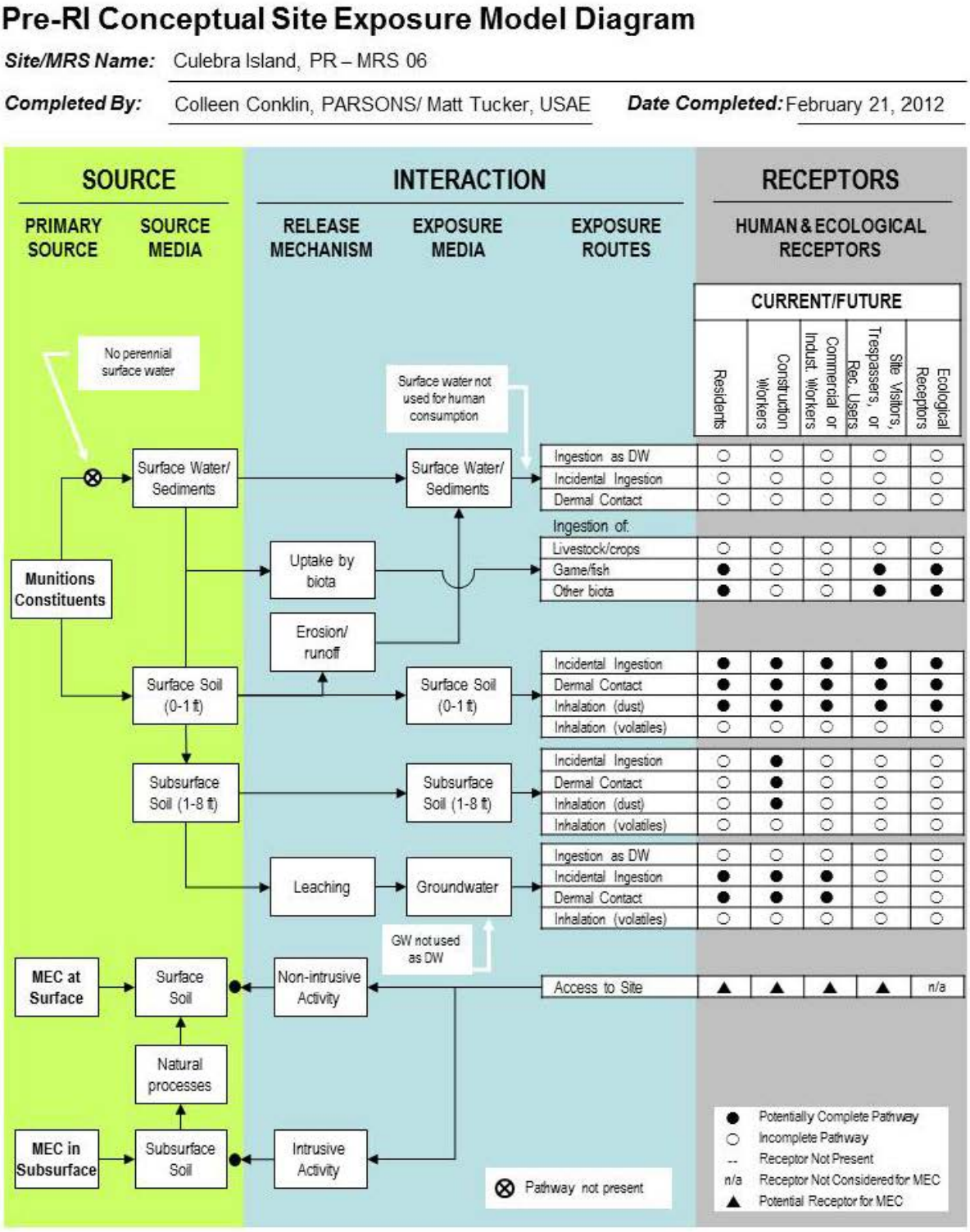


Figure 3-1: MRS 06 Pre RI CSM

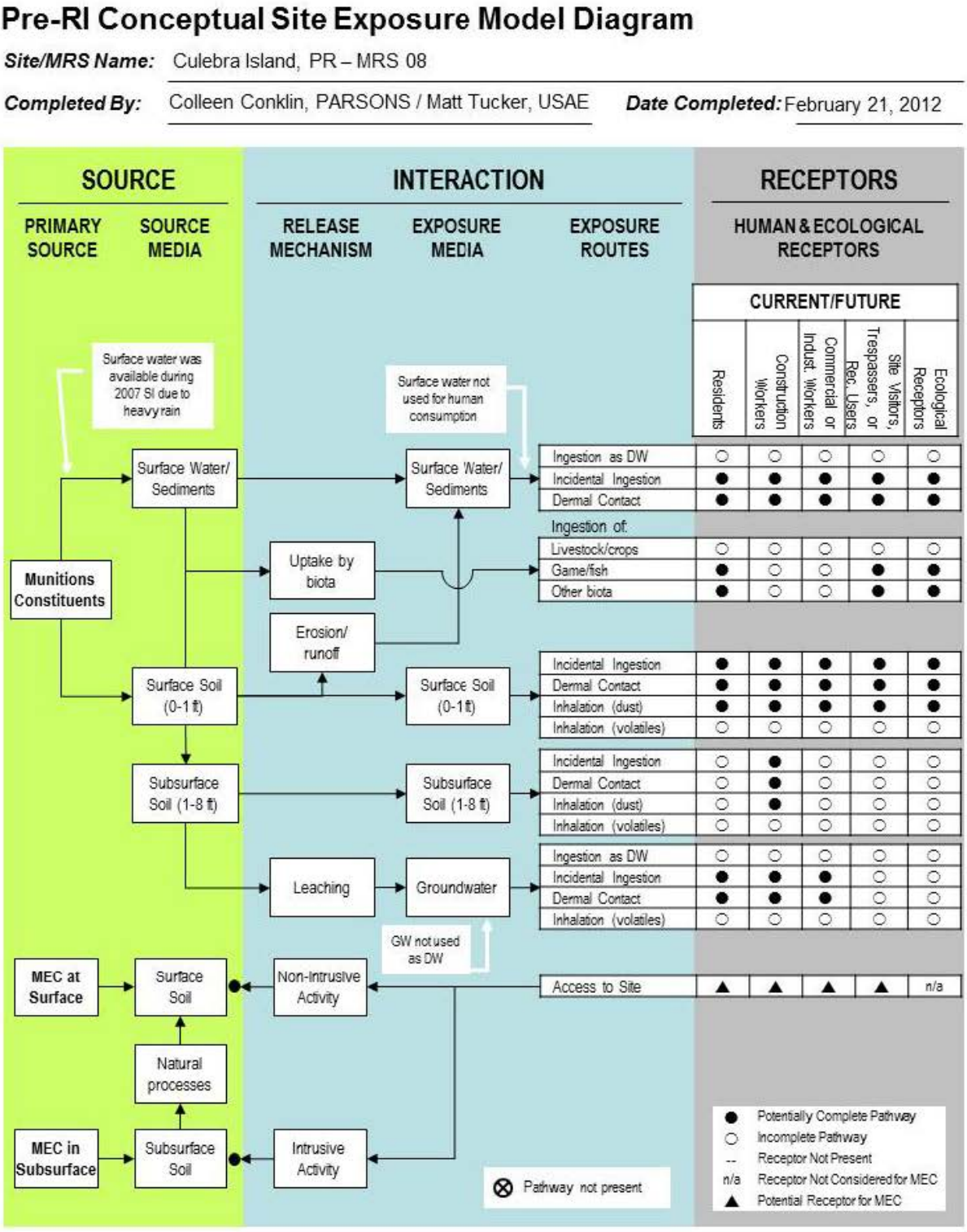
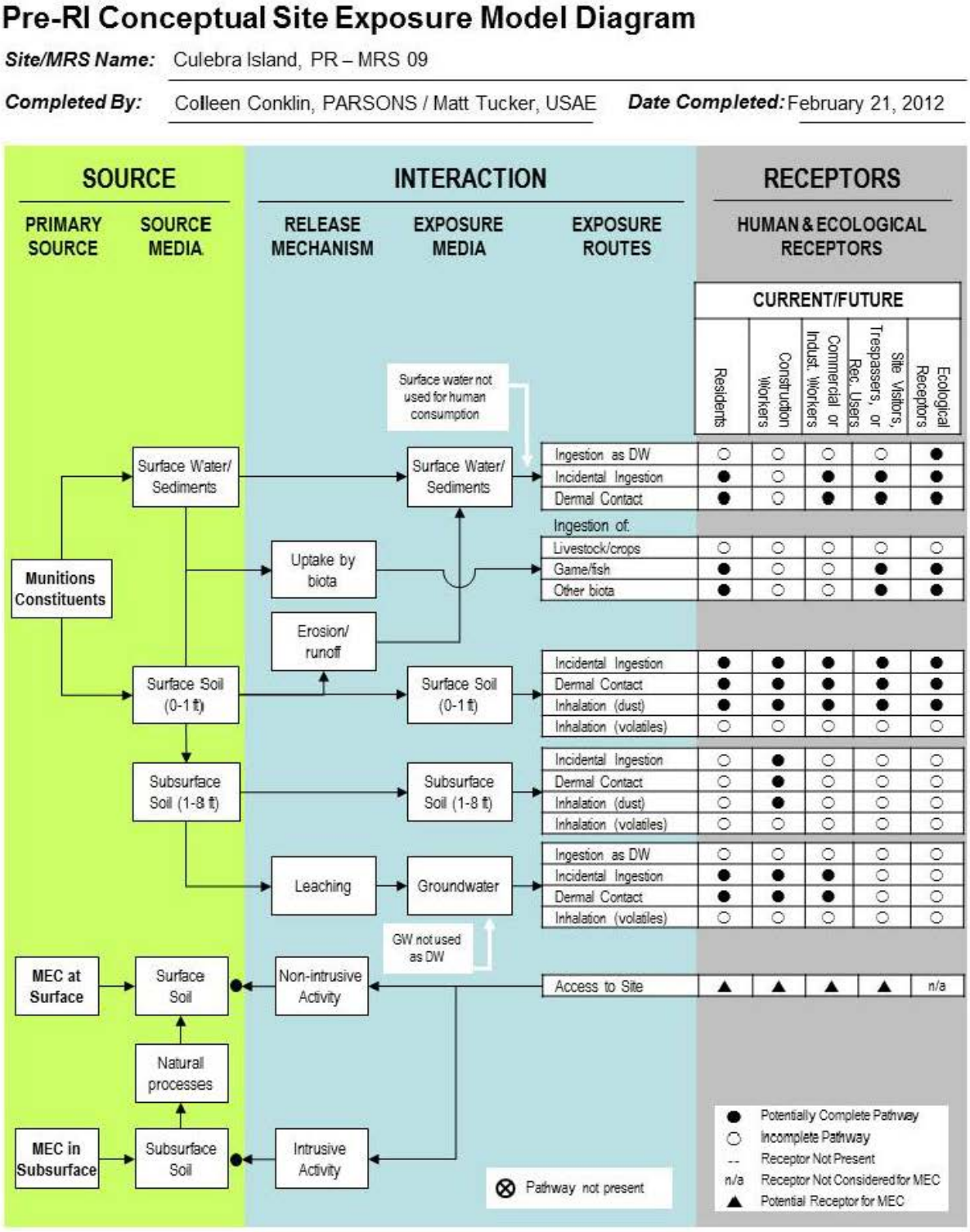


Figure 3-2: MRS 08 Pre-RI CSM

1201



1202

1203 **Figure 3-3: MRS 09 Pre-RI CSM**

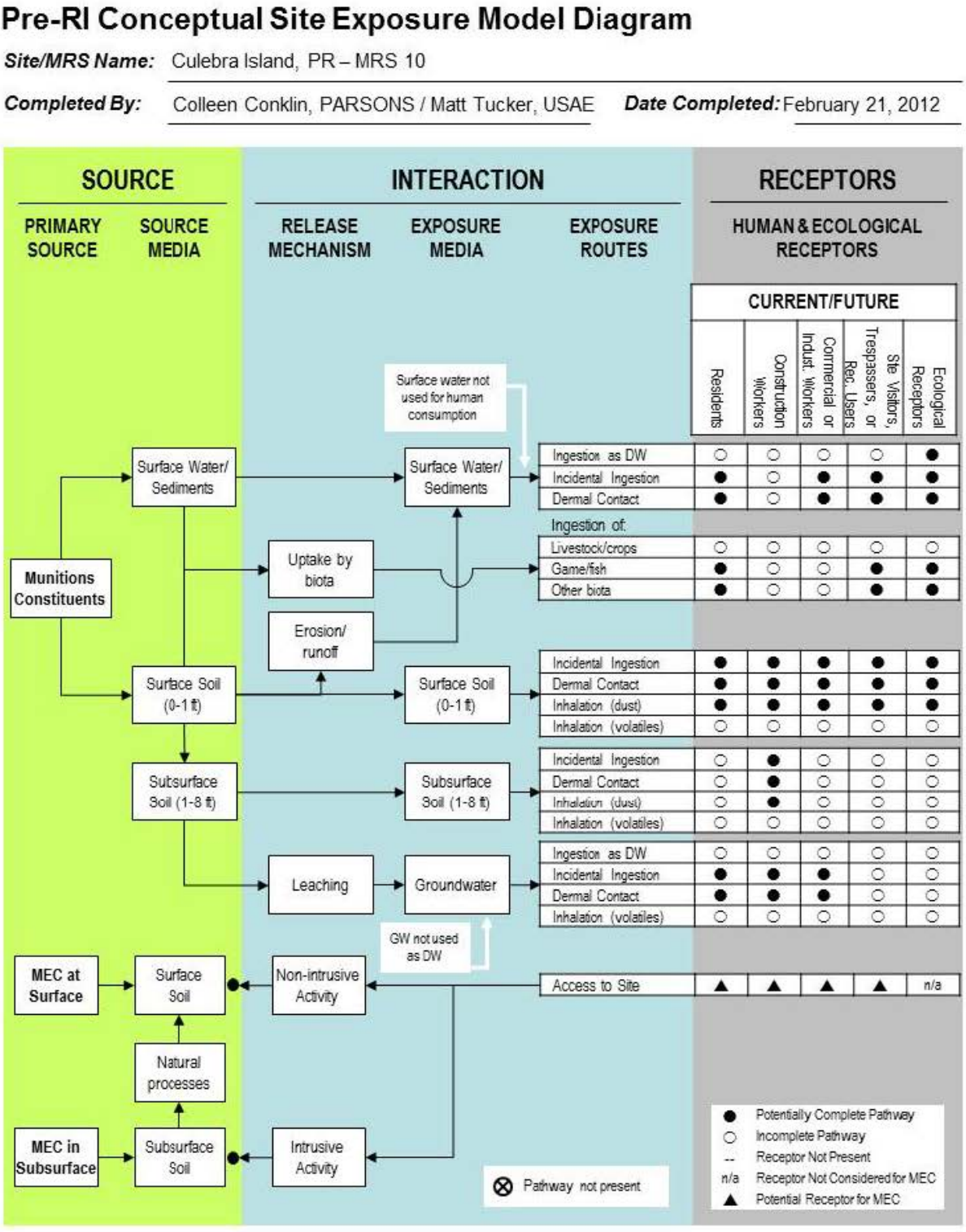


Figure 3-4: MRS 10 Pre-RI CSM

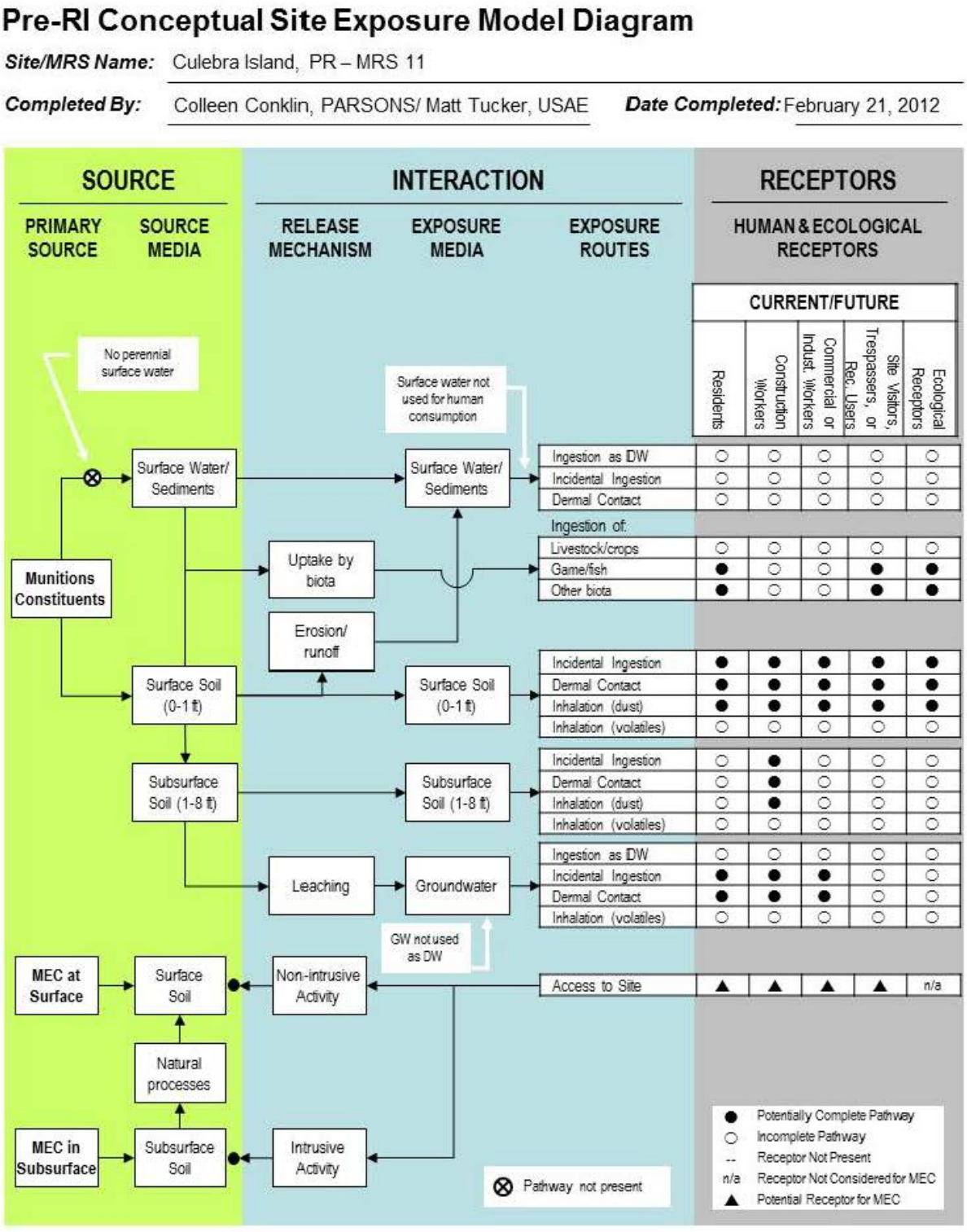


Figure 3-5: MRS 11 Pre-RI CSM

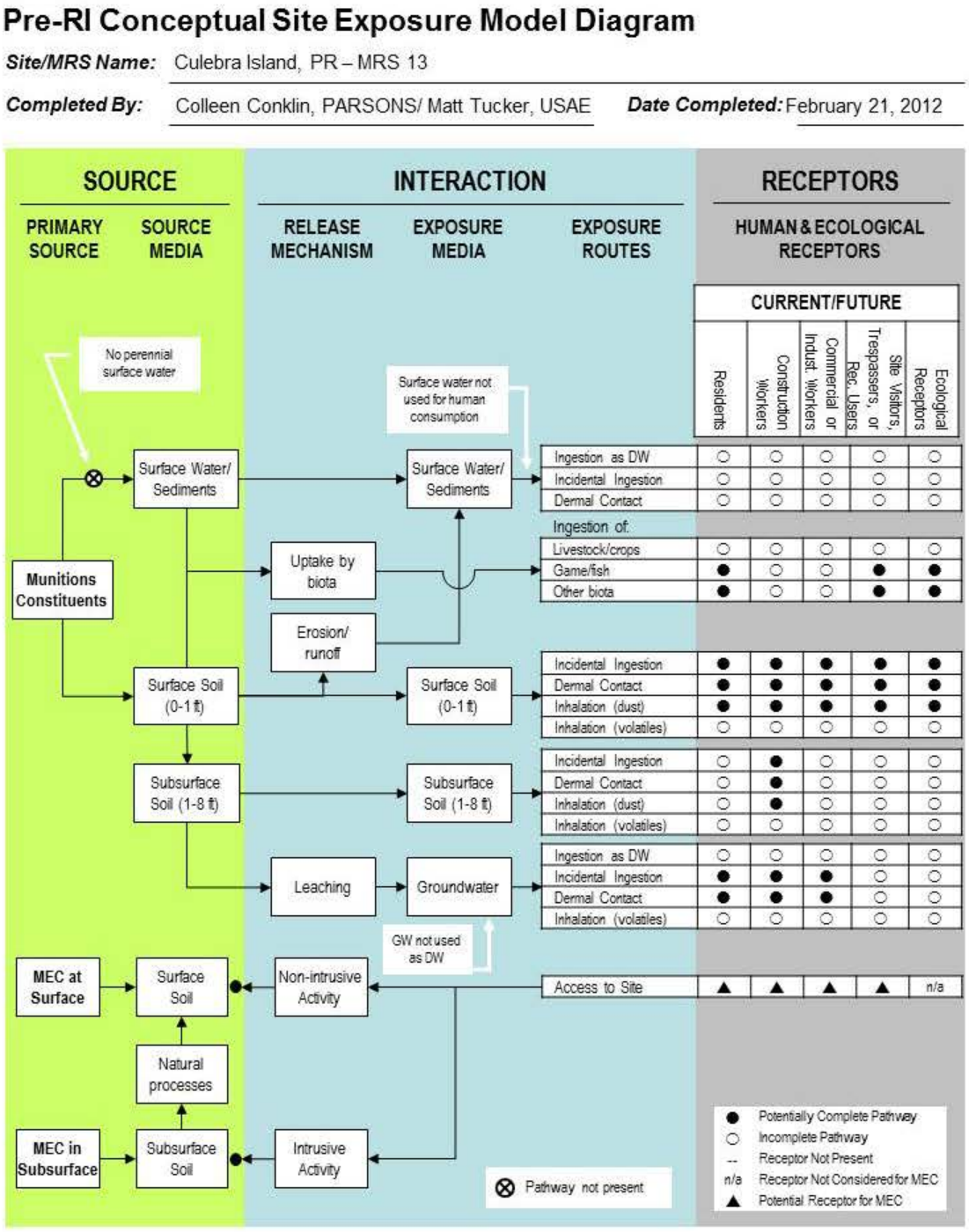


Figure 3-6: MRS 13 Pre-RI CSM

3.1.1 MRS 06 Artillery Firing Area

The Pre-RI CSM identified a potentially complete MEC exposure pathway for human receptors due to the potential presence of surface and subsurface MEC. Exposure pathways related to MC were identified as potentially complete for human and ecological receptors; therefore, an evaluation of MC was included in the RI for both human and ecological receptors. There is no evidence the lagoons in the MRS were used for target practice.

MRS 06 is easily accessible to improved areas such as residences and public beaches (Larga and Zoni Beaches). A majority of MRS 06 consists of heavily vegetated and steep terrain. Some areas can be difficult for human receptors to access. Based on the current and projected land use for additional residential development, access to undeveloped areas may increase.

The RI was designed to assess the presence / nature and extent of surface and subsurface MEC within MRS 06. The project approach included DGM and intrusive investigation of identified anomalies within the upland areas, analog mag-and-dig investigations within the beach areas, and MC sampling at locations where MEC or MD are identified.

3.1.2 MRS 08 Cayo Norte Impact Area

The Pre-RI CSM identified a potentially complete MEC exposure pathway for human receptors due to the potential presence of surface and subsurface MEC. Exposure pathways related to MC were identified as potentially complete for human and ecological receptors; therefore, an evaluation of MC was included in the RI for both human and ecological receptors.

MRS 08 is a privately owned island and is accessible only by boat. MRS 08 contains very few improved areas such as dirt roads/paths and a beach area. Given that all beaches in the Commonwealth of Puerto Rico allow public access, additional human receptors are able to access MRS 08. Based on the current and projected land use, a low amount of private residential development may occur in the future.

The RI was designed to assess the presence /nature and extent of surface and subsurface MEC within MRS 08. The project approach included DGM and intrusive investigation of identified anomalies within the upland areas, analog mag-and-dig investigations within the beach areas, and MC sampling at locations where MEC or MD are identified.

3.1.3 MRS 09 Soldado Point Mortar and Bombing Area

The Pre-RI CSM identified a complete MEC exposure pathway for human receptors due to the potential presence of surface and subsurface MEC. Exposure pathways related to MC were identified as potentially complete for human and ecological receptors; therefore, an evaluation of MC was included in the RI for both human and ecological receptors.

A majority of MRS 09 is administered by the PR DNER. A small amount of MRS 09 contains four residences and a portion of a hotel resort (northeast corner of MRS). Aside from this area MRS 09 contains no official improved areas. Although the current land use for the DNER portion of MRS 09 does not allow for development, some unauthorized developments (squatter houses) have been constructed within Sueno Cove. There is currently no controlled access to the DNER portion of MRS 09. This portion is easily accessible by a partially paved road through the center of the MRS. The paved portion stops at the top of Ensenada Dakity; however, an

unimproved road continues down into Sueno Cove and the beach areas. Based on the current and projected land use there are no plans to develop the DNER portion

The RI was designed to assess the presence /nature and extent of surface and subsurface MEC within MRS 09. The project approach included DGM and intrusive investigation of identified anomalies within the upland areas, analog mag-and-dig investigations within the beach areas, and MC sampling at locations where MEC or MD are identified. There is no evidence the lagoons in the MRS were used for target practice.

3.1.4 MRS 10 Defensive Firing Area No. 1

The Pre-RI CSM identified a potentially complete MEC exposure pathway for human receptors due to the potential presence of surface and subsurface MEC. Exposure pathways related to MC were identified as potentially complete for human and ecological receptors; therefore, an evaluation of MC was included in the RI for both human and ecological receptors.

MRS 10 is easily accessible to improved areas such as residential and commercial properties. The town of Dewey extends into the northern portion of the MRS. The western portion of MRS 10 consists of heavily vegetated and steep terrain that is currently undeveloped. This area can be difficult for human receptors to access. Based on the current and projected land use for additional residential development, access to undeveloped areas may increase.

The RI was designed to assess the presence /nature and extent of surface and subsurface MEC within MRS 10. The project approach included DGM and intrusive investigation of identified anomalies within the upland areas, analog mag-and-dig investigations within the beach areas, and MC sampling at locations where MEC or MD are identified.

3.1.5 MRS 11 Defensive Firing Area No. 2

The Pre-RI CSM identified a complete MEC exposure pathway for human receptors due to the potential presence of surface and subsurface MEC. Exposure pathways related to MC were identified as potentially complete for human and ecological receptors; therefore, an evaluation of MC was included in the RI for both human and ecological receptors.

MRS 11 is easily accessible to improved areas such as residential and commercial properties. The eastern portion of MRS 11 contains the majority of residential and commercial properties in Culebra. The northern portion of MRS 11 contains the municipal landfill and is adjacent to the NWP Bombardment area. The western portion of MRS 11 consists of heavily vegetated and steep terrain which contains limited residential and public beach areas (Tamarindo and Melones beaches). Portions of this MRS can be difficult for human receptors to access. MRS 11 contains six public beach areas that are frequented by residents and tourists. Based on the current and projected land use for additional residential and commercial development, access to undeveloped areas may increase.

The RI was designed to assess the presence /nature and extent of surface and subsurface MEC within MRS 11. The project approach included DGM and intrusive investigation of identified anomalies within the upland areas, analog mag-and-dig investigations within the beach areas, and MC sampling at locations where MEC or MD are identified. There is no evidence the lagoon in the MRS was used for target practice.

3.1.6 MRS 13 Cayo Luis Pena Impact Areas

The Pre-RI CSM identified a potentially complete exposure pathway for human receptors due to the potential presence of surface and subsurface MEC. Exposure pathways related to MC were identified as potentially complete for human and ecological receptors; therefore, an evaluation of MC was included in the RI for both human and ecological receptors.

MRS 13 is an island and is accessible only by boat. MRS 13 is administered by USFWS and is part of the Culebra Wildlife Refuge. MRS 13 contains very few improved areas consisting of a single road/path that leads up to the old helipad. MRS 13 contains established beach areas. Given that all beaches in the Commonwealth of Puerto Rico allow public access, additional human receptors are able to access MRS 13. Current and projected land use is to remain as a wildlife refuge.

The RI was designed to assess the presence /nature and extent of surface and subsurface MEC within MRS 13. The project approach included analog instrument assisted reconnaissance along the main trail to the helipad area, analog mag-and-dig investigations within the beach areas, and MC sampling at locations where MEC or MD are identified.

3.2 PRELIMINARY REMEDIATION GOALS

Preliminary remediation goals (PRGs) are both site- and contaminant-specific and define the conditions considered by stakeholders to be protective of human health and the environment. There may be PRGs for MEC and MC at each site evaluated during a RI. As with the CSM, PRGs may be reevaluated and refined throughout the RI process as new information becomes available.

To develop the PRGs for MEC and MC, the Culebra Island MRSs required sufficient characterization of the presence of MEC and MC. MEC/MD were characterized in these areas based on DGM and intrusive data collected during the RI. Environmental samples were collected and analyzed in order to characterize MC contamination.

3.2.1 Preliminary Remediation Goal for MEC

The PRG for MEC at all six of the Culebra Island MRSs is to reduce interaction of human receptors with MEC by eliminating or reducing exposure pathways through removal actions, land use controls, and/or educational awareness programs.

3.2.2 Preliminary Remediation Goal for MC

The PRG for MC contamination at all six of the Culebra Island MRSs is to ensure that identified MC contamination presenting an unacceptable risk to human health or the environment as determined in a baseline risk assessment will be addressed through removal actions, land use controls, and/or educational awareness programs to minimize or mitigate risks to human health and ecological receptors in the environment.

3.3 PRELIMINARY IDENTIFICATION OF ARARS AND TBC INFORMATION

Response actions under FUDS must identify and attain or formally waive Applicable, Relevant, and Appropriate Requirements (ARARs) under Federal and State laws (ER 200-3-1). Although the RI is not considered a response action, preliminary identification of chemical-specific and

location-specific ARARs was conducted during RI site characterization. ARARs are used as a "starting point" to determining the protectiveness of a site remedy. When ARARs do not exist for a particular chemical or remedial activity, other criteria, advisories, and guidance referred to as To Be Considered (TBC) are useful in designing and selecting a remedial alternative. A list of ARARs and TBCs that are specific to the Culebra Island MRSs are included in Table 3-1.

Table 3-1: ARARs and TBCs for the Culebra Island MRSs

Location-Specific ARARs	
The Endangered Species Act (USC) Title 16 chapter 35§1536 (a)(2)	Protects federal listed species located within Culebra Island MRSs by regulating takes of listed species.
Action-Specific ARARs	
RCRA Subpart X 40CFR Part 264	Establishes Solid Waste Management rules related to explosive waste management during clean up actions
The Migratory Bird Treaty Act; 16 USC § 704	Establishes rules for preventing take of listed migratory bird species
Action-Specific TBCs	
Local Conservation Goals	Possible TBC for limiting vegetation removal. Specific citations to be added to the FS.
EPA Preliminary Screening Values	Establishes screening levels for specific contaminants of concern.
PREQB Water Quality Standards and EPA Preliminary Screening Levels	Establishes screening levels for specific contaminants of concern.

As the RI/FS process continues, the list of ARARs and TBCs are updated, particularly as guidance is issued by state and federal agencies. ARARs and TBCs were used as a guide to establish the appropriate extent of site cleanup; to aid in scoping, formulating, and selecting proposed treatment technologies; and to govern the implementation and operation of the selected remedial alternative. As the ARARs are further developed and refined as part of the FS, primary consideration will be given to remedial alternatives that attain or exceed the requirements of the identified ARARs and TBCs. Throughout the RI/FS phase, ARARs and TBCs are identified and used by taking into account the following:

- Contaminants suspected or identified to be at the site
- Chemical analysis performed, or scheduled to be performed
- Types of media (soil, surface water, and sediment)
- Geology and other site characteristics
- Use of site resources and media
- Potential contaminant transport mechanisms
- Purpose and application of potential ARARs and TBCs
- Remedial alternatives considered for site cleanup.

Chemical-specific ARARs are promulgated health-based or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment. Risk-based screening levels [e.g., USEPA Regional Screening Levels (RSLs)] are not chemical-specific ARARs because they are not promulgated; however, risk-based screening levels can be considered chemical-specific TBCs. The PREQB WQS and USEPARSLs, May 2012 (Soil, Surface Water, and Sediment) and November 2013 (Groundwater), have been identified as chemical-specific TBCs for MC.

Location-specific ARARs generally are restrictions placed on the concentration of hazardous substance or the conduct of activities solely because they are in special locations. An action in these locations may cause irreparable harm, loss, or destruction of ecological resources. The Endangered Species Act [USC Title 16 chapter 35§1536 (a)(2)] has been identified as location-specific ARARs.

Action-specific ARARs are usually technology- or activity-based requirements or limitations placed on actions taken with respect to remedial/removal actions, or requirements to conduct certain actions to address particular circumstances at a site. RCRA Subpart X (40 CFR Part 264) and the Migratory Bird Treaty Act; 16 USC 704 are considered to be action-specific ARARs for the Culebra Island MRSs. In addition, a limitation for vegetation removal in support of removal actions may be included as a TBC for all MRSs.

3.4 SUMMARY OF INSTITUTIONAL ANALYSIS

The Institutional analyses is prepared to support the development of institutional control strategies and plans of action as a munitions response alternative. These strategies rely on existing powers and authorities of government agencies to protect the public at large from MEC risks.

A review of government institutions and private entities that exercise jurisdiction and ownership of the areas indicated that the property encompassing the Culebra Island MRSs was under the varying levels of jurisdiction of several agencies including the Municipality of Culebra; the Commonwealth of Puerto Rico (PR EQB and DNER); and the United States government agencies (USFWS and USACE). The role of each of these agencies is summarized below.

3.4.1 Municipality of Culebra

The Culebra Island MRSs lie entirely within the island of Culebra, which is locally governed by a municipality. The municipality oversees building permits, fire, police, and emergency management responsibilities, and land use controls over municipal properties. The municipality has numerous joint, mutual aid and planning agreements and other relationships with all levels of government and can assist and work with the USACE in developing land use controls related to the Culebra Island MRSs. The Municipality has also provided a member to serve on the Restoration Advisory Board (RAB) for Culebra.

3.4.2 Commonwealth of Puerto Rico

3.4.2.1 Department of Natural and Environmental Resources (DNER)

DNER serves as the Commonwealth's lead natural resource conservation agency. DNER is responsible for managing lands and waterways under its jurisdiction and enforcing compliance

with the Commonwealth's natural resource regulations. Representatives from DNER have participated as part of the TPP including attending meetings and reviewing and providing comments on project documents. The DNER also provides a member to serve on the Culebra RAB.

3.4.2.2 Puerto Rico Environmental Quality Board (PR EQB)

The PR EQB is the principal environmental protection regulator in Puerto Rico. Representatives from PR EQB have participated as part of the TPP including attending meetings and reviewing and providing comments on project documents. The PR EQB also provides a member to serve on the Culebra RAB.

3.4.3 United States Government Agencies

3.4.3.1 US Fish and Wildlife Service

The mission of the USFWS is to work with others to conserve, protect and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people. In Culebra USFWS is responsible for managing the Culebra National Wildlife Refuge, which is located in various portions of Culebra. USFWS is also responsible for managing other lands under its jurisdiction and enforcing compliance with federal regulations. Representatives from USFWS have participated as part of the TPP including attending meetings and reviewing and providing comments on project documents. USFWS also provides members to serve on the Culebra RAB.

3.4.3.2 U.S. Army Corps of Engineers

USACE is the lifecycle Project Manager for the Culebra Island FUDS program. USACE has no jurisdiction or authority in Culebra; however, USACE provided project coordination responsibilities including review of project plans and documents, obtaining rights-of-entry to properties in the work area, working with the news media and the public, and coordinating with federal, state, and local agencies on issues pertaining to implementation of this project and protection of ecological and cultural resources. Other responsibilities include coordinating any necessary evacuations, providing proper notifications to the DNER, notifying the National Response Center and state officials in the event of a release or spill, and signing the hazardous waste manifests as the generator of any hazardous waste.

The DERP is the primary funding source, and USACE is the executor for conducting CERCLA projects on Culebra FUDS. The USACE is the implementing agency for execution of this project, providing technical expertise for MEC and MC activities, and serving as the technical manager for conducting the RI/FS. USACE responsibilities include procurement and direction of the prime contractor (USA Environmental, Inc.) and supporting agencies, and the coordination of document reviews and approvals. USACE also provides the on-site UXO-Qualified Safety Specialist.

3.5 DATA NEEDS AND DATA QUALITY OBJECTIVES

3.5.1 Data Needs

Previous studies of the Culebra Island MRSs, including the SI Report (Parsons, 2007), the ASR (USACE, 1995), and the ASR Supplement (USACE, 2005), were reviewed prior to developing

the RI/FS Work Plan. Although no MEC was found during the SI fieldwork, an RI/FS was to be recommended due to the presence of MD on the surface and historical records. The data needs for the RI/FS project (i.e., assessment of MEC and MC throughout the MRSs) were reviewed by the TPP Team. Data quality objectives (DQOs) associated with the data to be collected during the RI were developed by the TPP Team and included in the WP.

Several suggestions and requests by the TPP Team affected the type of data to be collected as part of the RI. During the TPP, stakeholders agreed to the following:

- To conduct geophysical investigations in the upland portions of each MRSs (excluding MRS 13) along transects and grids. Vegetation removal would be required prior to conducting DGM surveys. Endangered species mitigation measures (SOPs) would need to be employed while completing vegetation removal. DGM data would be initially collected along transects with an EM-61 Mk2. DGM transect anomalies within each MRS would be subsequently processed to produce an anomaly density map to guide grid placement for characterizing high anomaly density areas.
- Intrusive investigations would be conducted within upland area grids and within beach areas of each MRS, with the exception of MRS 13, where only beach digs were completed. Note: Per a USFWS request, the upland area grids were replaced with analog transect investigation of established trails as a less destructive method of investigation to the environment. The MRS 13 investigation was supplemented with visual surface reconnaissance from a 2009 post award site visit.
- The TPP agreed on the recommended laboratory analyses to be conducted on the environmental samples collected. Metals (minus essential nutrients) were to be analyzed via method SW6010B and SW6020 (mercury - SW7470) and explosives by method SW8330A. For samples that are designed to investigate the extent of a previously detected constituent, the analyses would be limited to that constituent.

3.5.2 Data Quality Objectives

Data quality objectives are qualitative and quantitative criteria used to guide sample collection and analysis activities. The DQOs for this RI/FS project were developed prior to conducting investigative activities to ensure that the data generated during the execution of the analytical program are of appropriate quality to support the anticipated end use of the data. The DQOs follow the seven step process established in the U.S. Environmental Protection Agency (EPA) QA/G-4HW Guidance. DQOs seek to ensure that the right type, amount, and quality of data are collected to accomplish the objectives of the project. Below are the seven DQO steps from the EPA guidance.

1. State the Problem
2. Identify the Decision
3. Identify the Inputs to the Decision
4. Define the Study Boundaries
5. Develop a Decision Rule
6. Specify Limits of the Decision Errors
7. Optimize the Design for Obtaining Data

1472 Table 3-2 reflects the DQOs for the RI data collection activities. These DQOs were taken from
1473 the Final RI Work Plan approved by the TPP.

1474 **Table 3-2: Project DQOs**

Step	Culebra Island MRSs (Terrestrial)
1. State Problem(s)	• Define the nature and extent of MEC contamination relative to future land use, potential receptors, and accessibility within MRSs • Define the nature and extent of MC contamination relative to future land use, potential receptors, and accessibility within MRSs
2. Identify the Decision	• Determine where *surface and subsurface* MEC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary • Determine where surface soil, subsurface soil, surface water, groundwater and sediment MC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary * *For the purposes of this DQO: "accessible" means that access has not been hindered by slopes in excess of 33 degrees, dense vegetation, natural barriers, or any combination of the above.*
3. Identify the Inputs	• Future Land Use, Potential Receptors, and Access (CSM) • Historical Records (SI & ASR) • Presence of MEC items on the surface or subsurface in prescribed transects and grids (Trails and beaches only in MRS 13). MRS 13 further evaluated with surface reconnaissance results from 2009 post award site visit. • Concentration value of MC taken from discrete surface soil, subsurface soil, surface water, sediment, and groundwater samples, including step-out areas if applicable. One (1) discrete sample per applicable media, per location. • Hydraulic conductivity established from slug test data.
4. Define the Study Boundary	The MRS boundary defines the population to be sampled and the decision unit to which the data will be applied. The populations of MEC to be sampled are on the surface and subsurface within the MRSs. The populations to be sampled for MC are surface and subsurface soil, surface water, and sediment. <u>MEC:</u> • Locations on the *surface* and *subsurface* within the MRSs (Analog mag-and-dig on trails and beaches in MRS 13). MRS 13 investigation supplemented by 2009 visual surface reconnaissance from post award site visit. <u>MC:</u> • Surface and subsurface soil sampling locations will be established based on locations of MEC/MD discovered during the geophysical investigation. Surface water samples will be collected in areas near streams and shorelines down gradient from areas containing MEC/MD discovered during the geophysical investigation • Surface water and sediment samples will be collected from down gradient streams and depositional areas down gradient from areas containing MEC/MD discovered during the geophysical investigation.

Step	Culebra Island MRSs (Terrestrial)
	• Groundwater samples will be collected from wells identified in the groundwater survey, and any well that is installed.
5. Develop a Decision Rule	The following decision rules will be applied to the MEC population and decision unit: • If MEC is discovered on the surface and/or subsurface of an MRS then a baseline MEC Hazard Analysis (MEC HA) based on future land use, potential receptors, and access will be performed and presented to the project team for further evaluation. • The MEC investigation will be halted if and when project objectives are met, (e.g., nature and extent of MEC has been determined for an MRS or a portion of an MRS*.) If the project objectives for MEC have not been met, grid or transecting step out processes will be implemented to collect additional data required to further bound the nature and extent of MEC contamination. * Criteria taken from EM-1110-1-4009, Chapter 7, Site Characterization. The following decision rules will be applied to the MC population and decision unit: <u>Surface and Subsurface Soil</u>: If MC concentrations for each sample site are less than the screening values identified in Worksheet #15 of the UFP QAPP, then no further action for that area will be considered as it is delineated. If MC concentrations for each sample site are greater than the screening values identified in Worksheet #15, Step-out sampling will be conducted IAW the Step-out procedure Flow Chart included in the Sampling and Analysis Plan (SAP) in Appendix E. Step-out sampling will continue until MC concentration is at or below screening criteria, in which the contamination shall be delineated. <u>Surface water and sediment:</u> If MC concentrations for all sample sites are less than the screening values identified in Worksheet #15, then surface water at that site will not be considered to impact surface water or sediments within the MRSs. If a concentration exceeds the screening values for a given location, additional downstream samples will be collected until MC concentration is at or below screening criteria, in which the contamination shall be delineated. <u>Groundwater</u> If MC concentrations for all sample sites are less than the screening values identified in Worksheet #15 of QAPP, then MC at that MRS will not be considered to impact groundwater. If a concentration exceeds the screening values for a given location, a determination will be made by the PDT if more samples are needed to delineate contamination.
6. Specify Limits on Decision Errors.	Measurable decision errors are limited to the field and analytical QC processes. The analytical requirements for MC are defined on Worksheet #12 of the UFP QAPP. Slug testing procedures are defined in the Aquifer Testing SOP included in Appendix K.
7. Optimize the Design for Obtaining Data	Data collection procedures and associated QC for MEC are included in the RI/FS Work Plan. MC sample design and rationale is listed on Worksheet #17 of the UFP QAPP.

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3.5.2.1 Digital Geophysical Mapping and Investigation of Geophysical Anomalies

DGM was conducted to determine the location and concentration of anomalies which could be MEC. DGM was conducted in upland areas of the Culebra Island MRSs within 50-ft by 50-ft grids. Note: Per a USFWS request, the upland area grids in MRS 13 were replaced with analog transect investigation of trails as a less destructive method of investigation to the environment. Only anomalies meeting the established threshold and classification (i.e., attributed to MEC) were investigated. DGM activities were considered complete when the selected DGM anomalies were investigated and sufficient data was collected to support the FS. The DQOs for DGM activities conducted the Culebra MRSs were met. Although ROE affected the original DGM investigation in portions of the MRSs, the data collected in the RI, supported by information from historical sources, the SI Report, and the 2009 post award site visit, contribute to meeting project DQOs. All QC considerations were met and are documented in Appendix J.

3.5.2.2 Analog Mag-and-Dig Investigations

Analog Mag-and-Dig investigations were conducted along the accessible beach areas of the Culebra Island MRSs and on selected accessible trails on MRS 13 Figure 4-6. Anomaly selections for each beach were pre-established in the field investigation section of the Work Plan and were based on the PWS. Teams flagged all analog anomalies for evaluation. The selected anomalies were intrusively investigated and sufficient data was collected to support the FS. The DQOs for analog mag-and-dig activities conducted at the Culebra MRSs were met.

3.5.2.3 MC Sampling

Environmental sampling was conducted during the field activities to assess for the presence of MC contamination at sites where MEC or MD was encountered during the RI, and at sites where demolition activities occurred. In accordance with the approved FSP and QAPP, environmental samples were collected from their respective media (Section 4.2). Sampling activities during the RI culminated in the collection of 90 environmental samples. The additional groundwater sampling resulted in four samples plus one QA and on duplicate. The data results for each sample were validated in accordance with the procedures identified in the work plan. Data validation was performed according to SW846 methodologies and DoD Quality System Manual, version 3. The DQOs for the collection, processing, and reporting of environmental samples are presented in the approved SAP in Appendix E of the WP. Sampling was conducted in accordance with the 2011 MC QAPP refined with results from the MEC investigation and updated in November 2013 to include a groundwater investigation.

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CHAPTER 4. CHARACTERIZATION OF MEC AND MC

This RI was performed in a manner consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Section 104, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), Sections 300.120(d)-300.400(e). Therefore, no federal, state, or local permits are required for any action taken on the site. The RI adheres to the DERP for FUDS and relevant U.S. Army Regulations and guidance for MEC programs.

4.1 MEC Characterization

4.1.1 General

This section provides details of the approach, methods, and operational procedures used for the geophysical data acquisition and associated data processing and intrusive investigation activities conducted for the characterization of MEC within the Culebra Island MRSs.

4.1.2 Identification of MEC Areas of Concern

The MEC areas of concern for the RI consisted of MRSs 06, 08, 09, 10, 11, and 13. The MEC areas of concern and history of the sites are described in detail in Chapter 2.

4.1.3 Site Access: Rights-of-Entry and Terrain Challenges

Prior to conducting RI field work, USA assisted the USACE in obtaining Rights-of-Entry (ROE) for all privately owned properties within the Culebra Island MRSs under the RI. ROE forms were mailed out in English and translated into Spanish as needed, a speaking local resident was hired to discuss with residents. ROE documents were executed by the USACE Jacksonville District Real Estate Office. All ROE documents related to the RI were tracked in a geographical information system (GIS) as they progressed through execution (Owner and USACE signatures). Property data was obtained in GIS format from the (Puerto Rico) Center for Collection of Municipal Revenues (CRIM). The CRIM is the official property tax collection agency of Puerto Rico. RI field work was conducted only in those properties where a ROE document had been executed. Sufficient ROE was obtained in all Culebra Island MRSs with the exception of MRS 06, where the RI transect design had to be adjusted to fit within areas where ROE was granted. ROE documentation is included in Appendix F. The areas where ROE was not obtained are shown on Figures 5-1 through 5-6.

Characterization was additionally impacted by unsafe slopes. Steep slopes were encountered throughout the MRSs. A generalized depiction of the slopes over 33 degrees is represented on Figures 5-1 through 5-6. In the areas that could be traversed the investigation proceeded, but when safety was a factor the slopes were avoided.

4.1.4 Remedial Investigation MEC Characterization Tasks

4.1.4.1 Vegetation Removal

Vegetation removal activities were conducted in undeveloped areas to provide access for DGM surveys on transects and grids. Vegetation teams consisted of UXO qualified personnel and subcontracted deforester labor. Prior to commencing with vegetation removal activities, a local field biologist provided the vegetation removal teams with training in endangered species identification and mitigation procedures. This training was in coordination with the endangered species mitigation SOPs (Appendix M of the WP). The Team Leader utilized a Trimble Pro XRT Differential Global Positioning System (DGPS), or equivalent, to follow each transect, following a path of least resistance to help minimize devegetation and avoiding all properties where a ROE had not been obtained. Vegetation removal teams utilized handheld saws and cutters to clear the footprints needed, a path approximately 5 feet wide for transects and a 50-foot x 50-foot area for grids.

While conducting vegetation removal activities in MRS 09, UXO Technicians recovered two Mk 25 Marine Marker flares. These items were deemed acceptable to move and were disposed of by a demolition shot on 26 May 2011 located within MRS 09. The two Mk 25 Marine Markers were the only MEC items recovered during the RI field work. The location where the items were found and the location where the demolition was conducted are shown on Figure 5-3. It should be noted this type of munition is incidental to the site and not necessarily indicative of DoD impact to the MRS. The Mk 25 Marine Markers are also frequently used by civilian vessels for training/man overboard indicators. These items were either washed up onto the shore or were picked up and placed on the shore. The Mk 25 Marine Markers are not used on land. They are incidental finds that cannot be used to characterize the land portion of the MRS.

Photograph 4-1: Vegetation Removal

4.1.4.2 Geophysical Investigation

This section provides details of the approach, methods, and operational procedures for the geophysical surveying and associated data processing for the RI. The geophysical investigation for the upland areas of the MRSs included DGM data collection along transects and in established grids. Per USFWS request, MRS 13 instrument-assisted reconnaissance was performed in lieu of DGM along all known upland trails and roads to identify surface MEC. Analog Mag-and-Dig was the investigation method chosen for the accessible beach areas due to the potential for anomaly migration along the shore lines.

4.1.4.2.1 Geophysical System Verification

Based on a previous agreement obtained during the TPP, a Geophysical Prove-Out would not be required and was replaced with a Geophysical System Verification (GSV) with an Instrument Verification Strip (IVS) Plan and Report. The IVS was located in the DNER property in MRS The complete GSV report is provided in Appendix J. Further details regarding the selection of the location, test items, and procedures followed are located in the report. In lieu of a GPO, daily analog and digital instrument response tests were performed each morning and afternoon over the IVS. A combination of small Industry Standard Objects (ISOs), intended to simulate 37mm projectiles, and large ISOs, intended to simulate 105mm projectiles or 4.2 inch mortars, were used in each IVS. The response curves for these ISOs are well documented for both the best case orientation (vertical) and the worst case orientation (horizontal). Four of each ISO were used: two horizontal at depths 3 and 7 times ISO diameter, and two vertical at the same 3 and 7 times diameter depth. EM61-MK2 responses for each seed item were compared to published response curves and daily repeatability to ensure the equipment performed as designed.

The test strip results and anomaly selection criteria were provided to the USACE Geophysicist prior to starting fieldwork. Any recommended changes to the anomaly selection criteria were discussed with USACE's Geophysicist prior to implementing. USA documented the GSV results in a Draft and Final Geophysical System Verification letter report (the Final GSV Report is provided in Appendix J) that documented IVS setup, digital geophysical detection results, grid line spacing test results, initial grid anomaly selection criteria, and recommended final DGM performance metrics. The test strip was installed in a designated area at the USFWS facility located on Culebra.

Photograph 4-2: Survey of IVS

4.1.4.2.2 Geophysical Investigation Plan

Subsequent to the acceptance of the GSV, USA proceeded to collect DGM transect data to satisfy the project DQOs of the RI. Transect acres were converted to miles, as provided for in the PWS, using 2.75 miles per transect acre as the conversion factor. All required grid acres were assigned to upland portions of each MRS (except MRS 13 where only accessible trails were investigated).. Table 4-1 provides the overall geophysical coverage for each of the Culebra Island MRSs. Figures 4-1 through 4-6 show the geophysical investigation coverage for each MRS.

Table 4-1: Geophysical Survey Coverage (Acreage)

MRS	Land Acres	DGM Transect Acres (Upland Areas)	DGM Grid Acres (Upland Areas)	Analog Transect Acres (Beach Areas)	Geophysical Acres	MRS Coverage
6	826	3.02	1.00	1.05	5.07	0.61%
8	306	1.44	0.50	0.35	2.29	0.75%
9	203	1.08	0.98	0.15	2.21	1.09%
10	522	4.18	0.98	0.29	5.45	1.04%
11	694	4.55	0.98	1.06	6.59	0.95%
13	484	0.00	0.00	2.00	2.0	0.41%

Transects were planned and conducted for each MRS, focusing on historical munitions use areas, covering as much of the MRS, including all beach areas, as executed ROE would allow. MRS terrain maps were used during the transect planning to follow MRS elevation contours as much as possible and to avoid slopes greater than 33 degrees.

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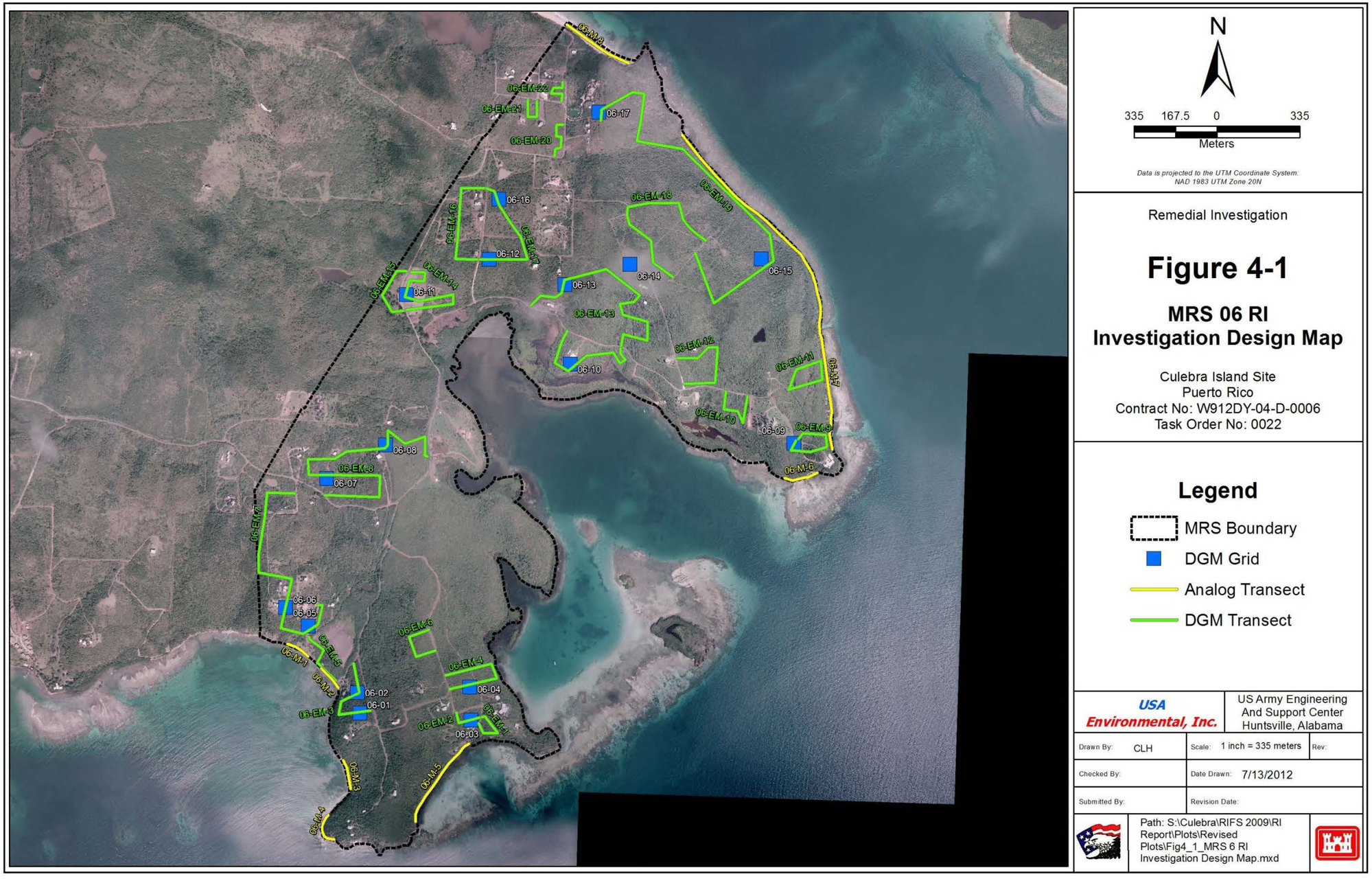

Figure 4-1: MRS 06 RI Design Map

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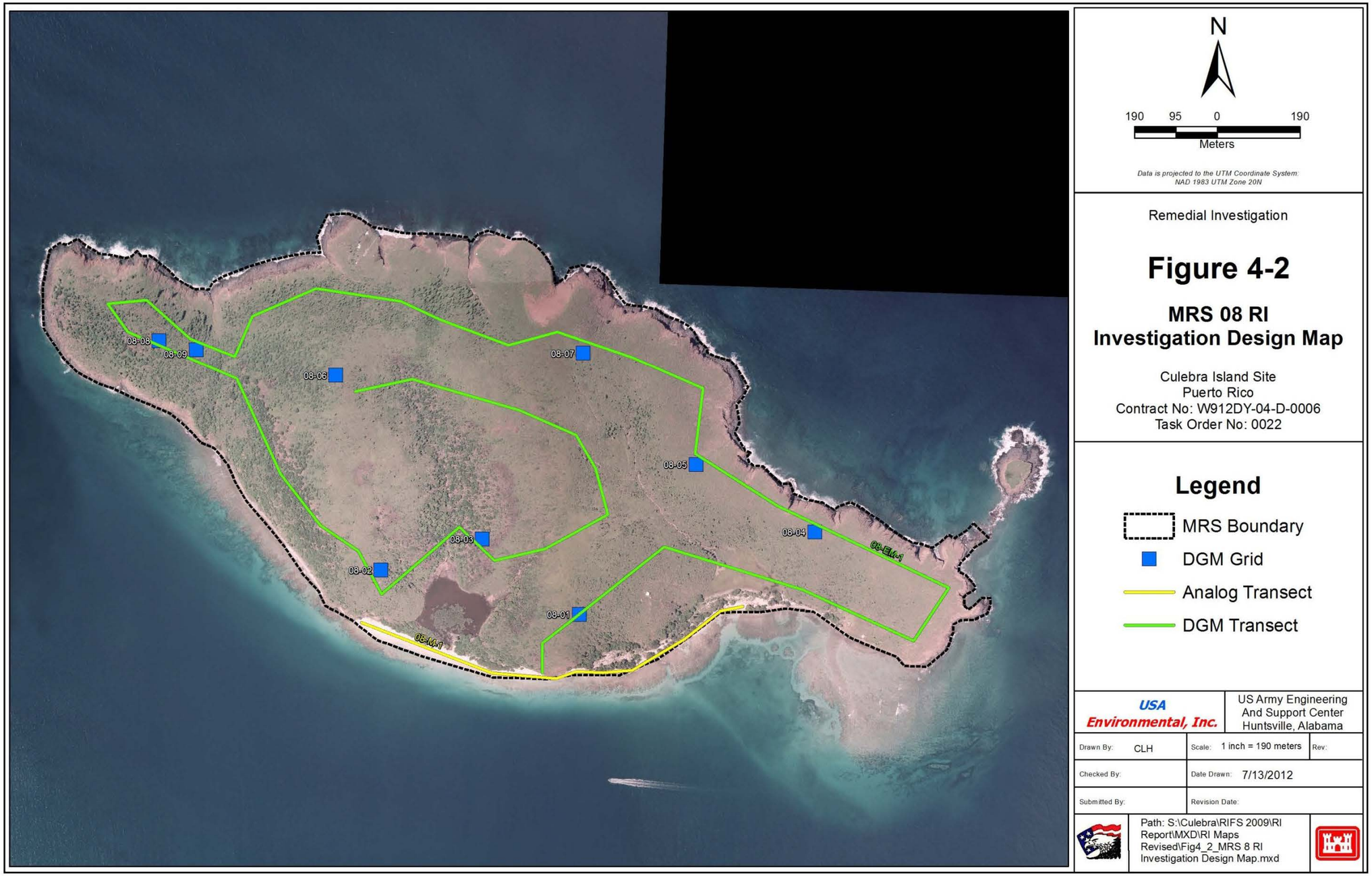

Figure 4-2: MRS 08 RI Design Map

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1631 **Figure 4-3: MRS 09 RI Design Map**

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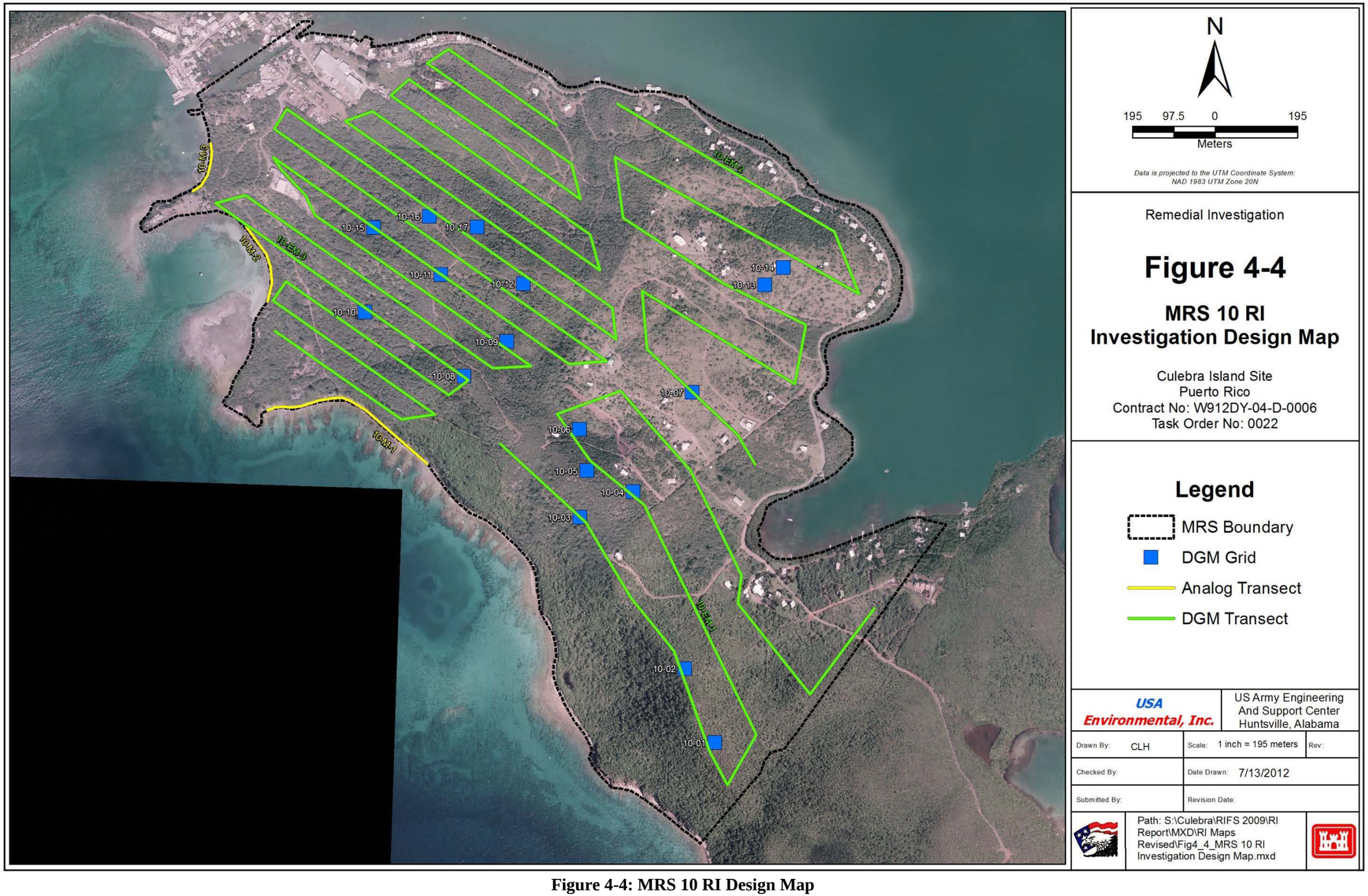

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Figure 4-4: MRS 10 RI Design Map

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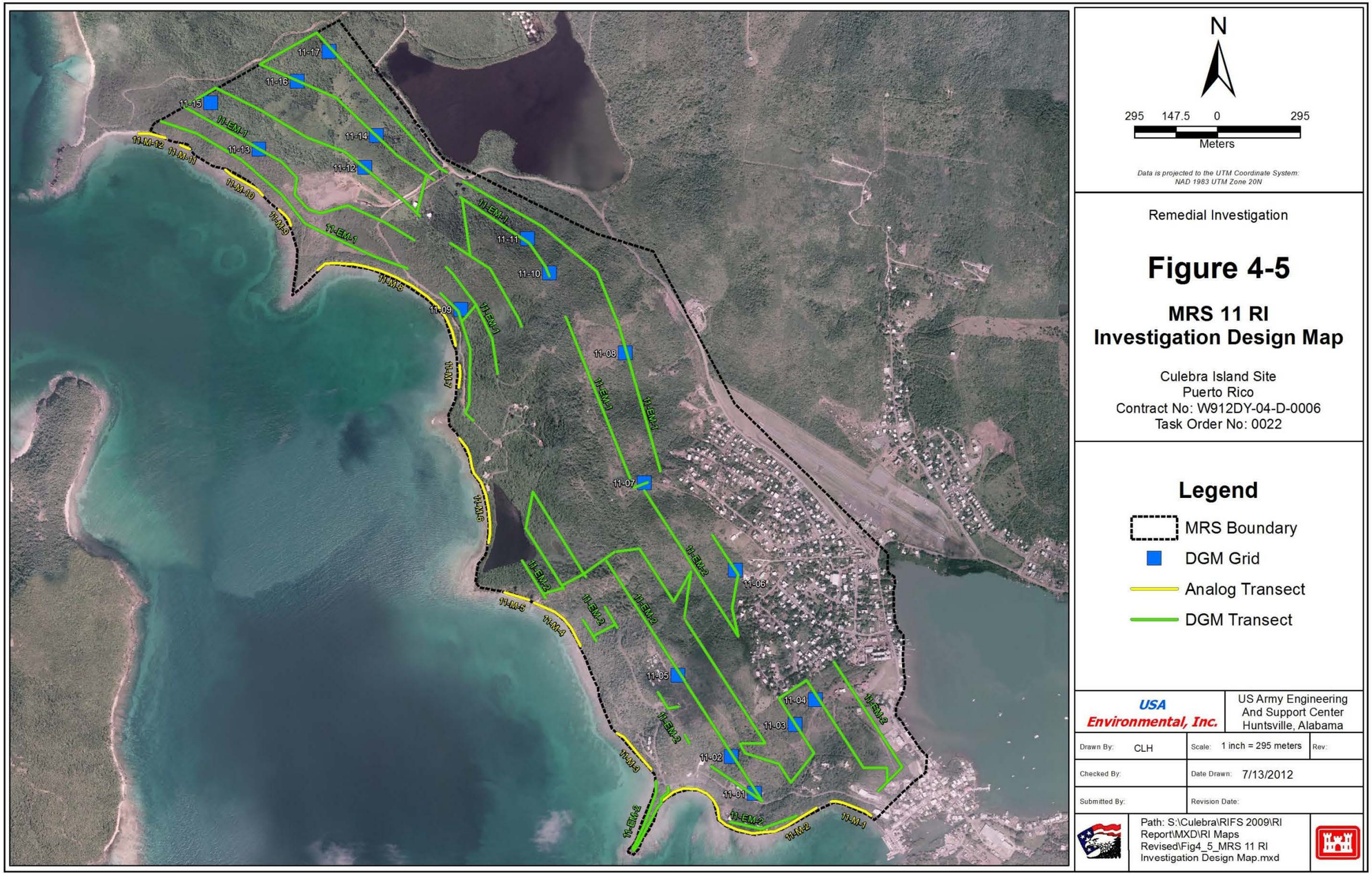

Figure 4-5: MRS 11 RI Design Map

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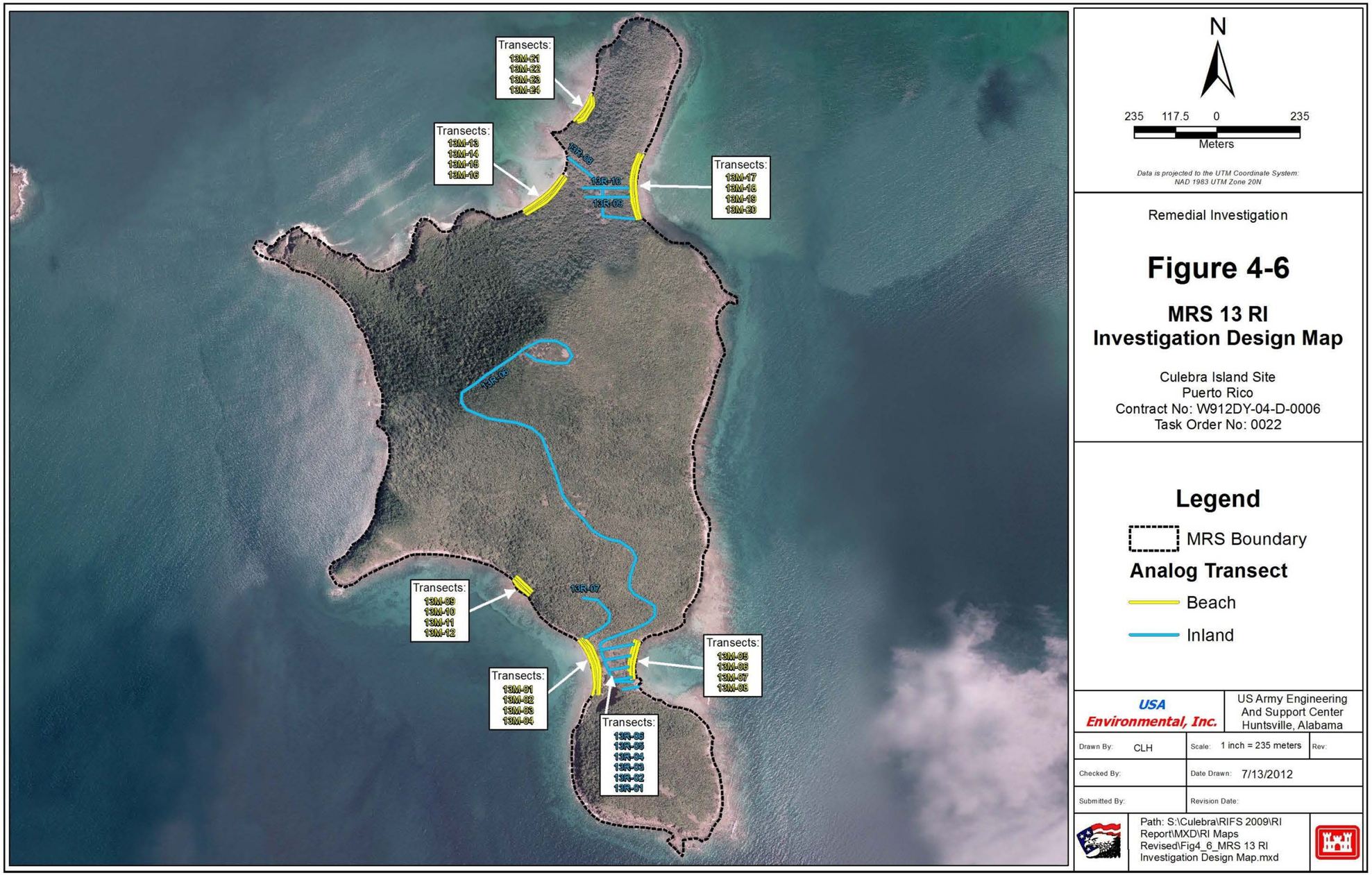

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Figure 4-6: MRS 13 RI Design Map

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4.1.4.2.3 DGM Surveys

Along upland transects, the EM61-MK2 was deployed in stretcher mode with the wide (1m) edge forward and positioned with a Trimble Pro XRT DGPS, with an external antenna mounted over the coil center. UXO technicians guided the DGM operators along each prepared transect using a Trimble GeoXT for guidance, following the path cleared and marked by the vegetation removal teams. Note: upland transects in MRS 13 were investigated by the analog mag-and-dig method. The DGM team maintained a field log book and up loaded survey data to the GIS daily. Selected DGM transect anomalies were loaded into the project GIS database and used to create anomaly density maps for each MRS. DGM performance metrics followed those listed in the PWS Table 7-1 Performance Requirements for RI/FS using DGM Methods. For purposes of data quality acceptance, the morning and afternoon transect data collections were considered two lots of DGM data.

DGM transect data was analyzed for potential MEC anomalies. These potential MEC anomalies were imported into the project GIS to create anomaly density maps, using ESRI's Spatial Analyst, for each MRS. High anomaly density areas that exceeded background density by a factor of 5 or more were considered potential target areas. Figures 4-7 through 4-11 show the resulting anomaly density maps for the Culebra Island MRSs. Proposed 50-ft x 50-ft grid locations were placed in the high density anomaly areas to provide the necessary data to establish the nature and extent of MEC contamination. Grid location maps were submitted to the USACE Geophysicist for review and approval.

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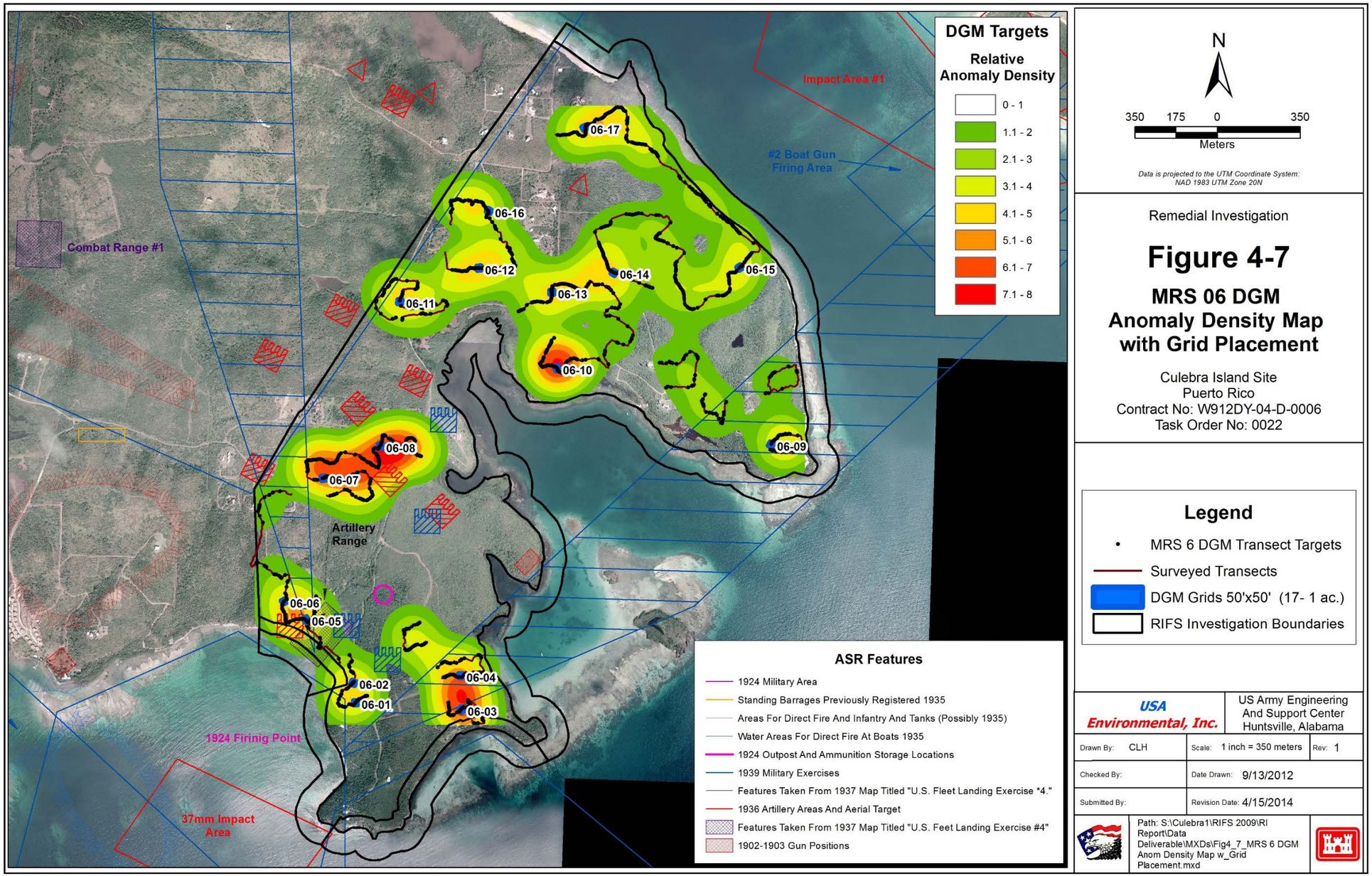

Figure 4-7: MRS 06 DGM Anomaly Density Map with Grid Placement

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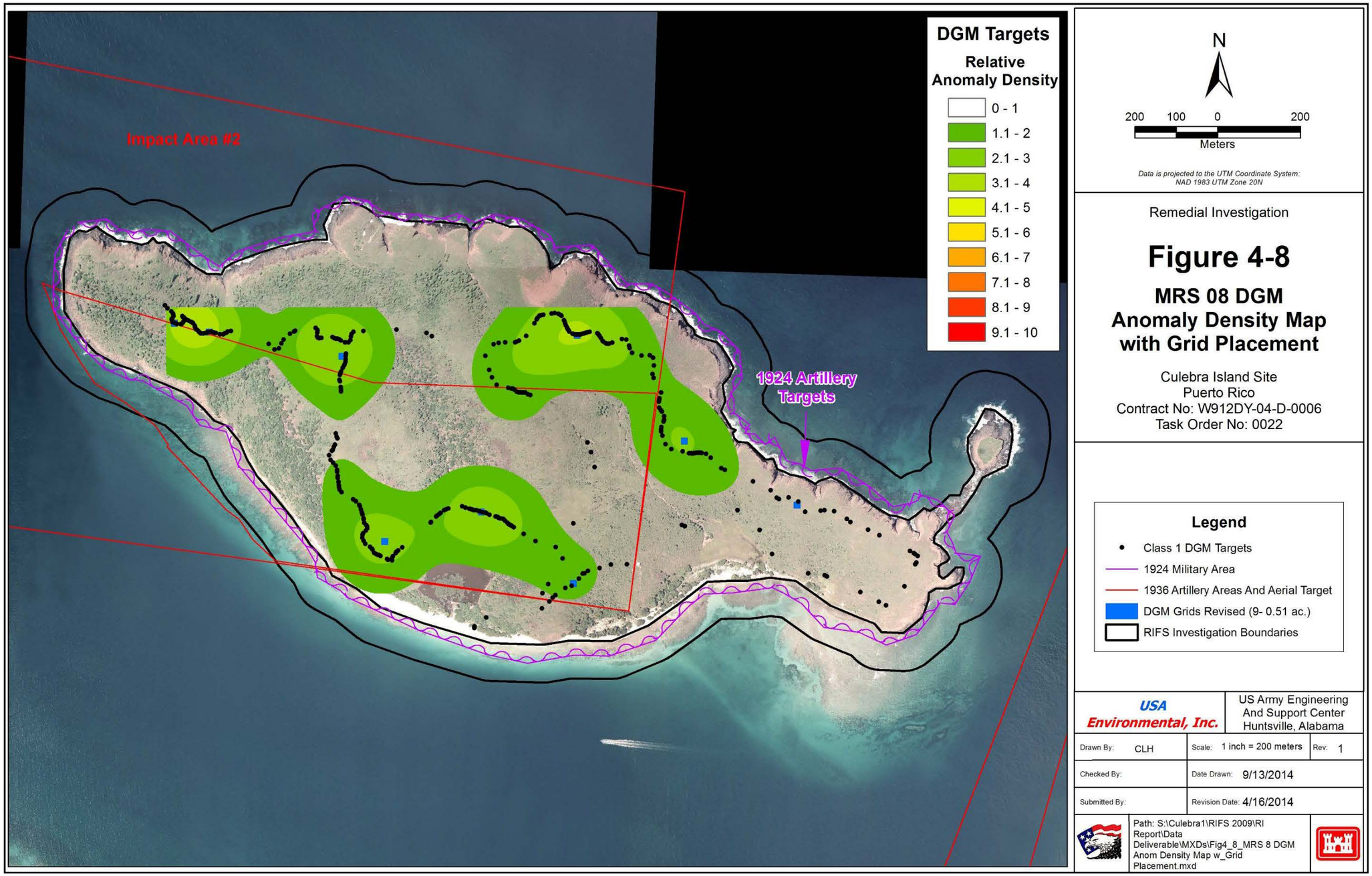

Figure 4-8: MRS 08 DGM Anomaly Density Map with Grid Placement

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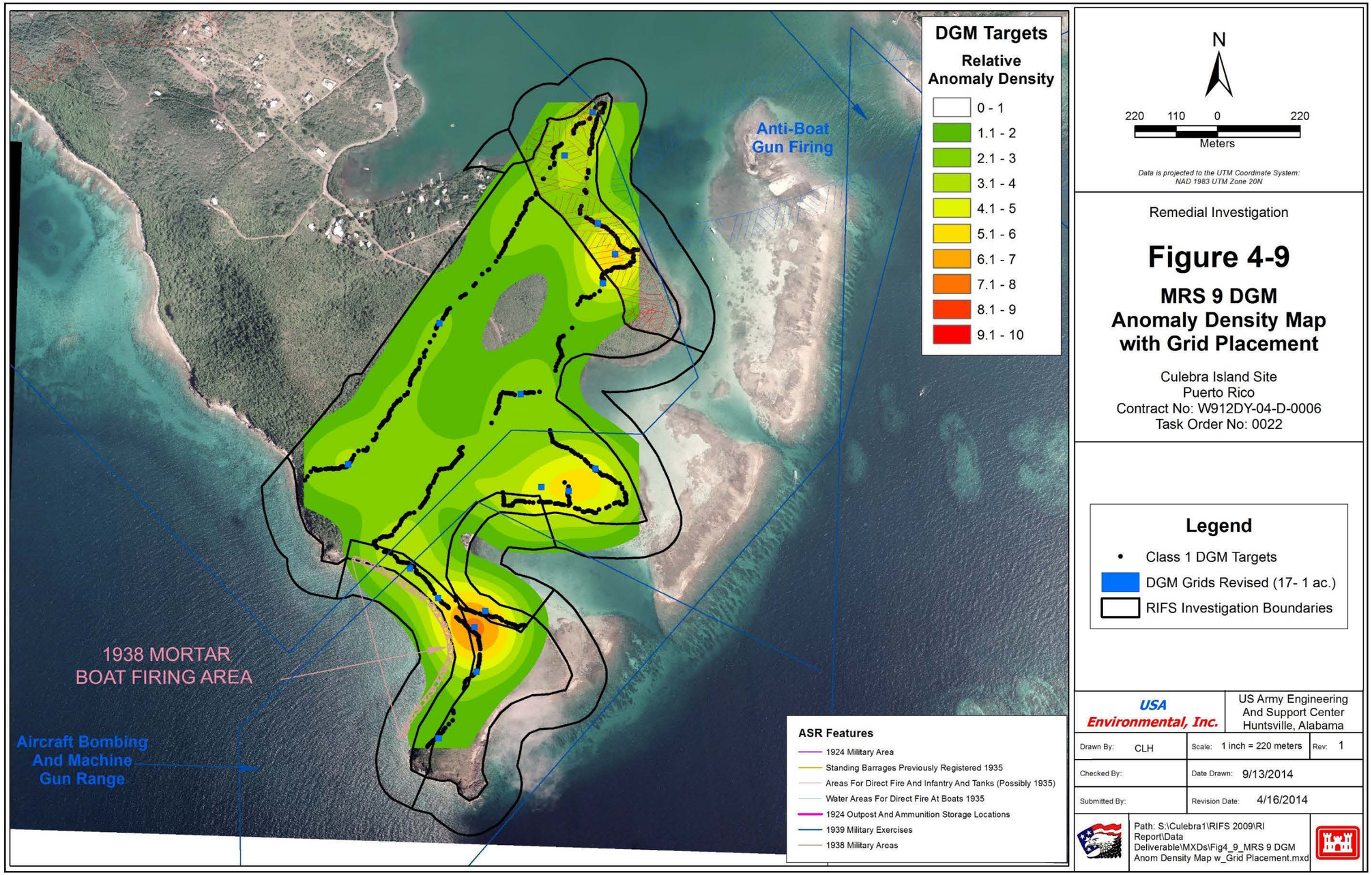

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Figure 4-9: MRS 09 DGM Anomaly Density Map with Grid Placement

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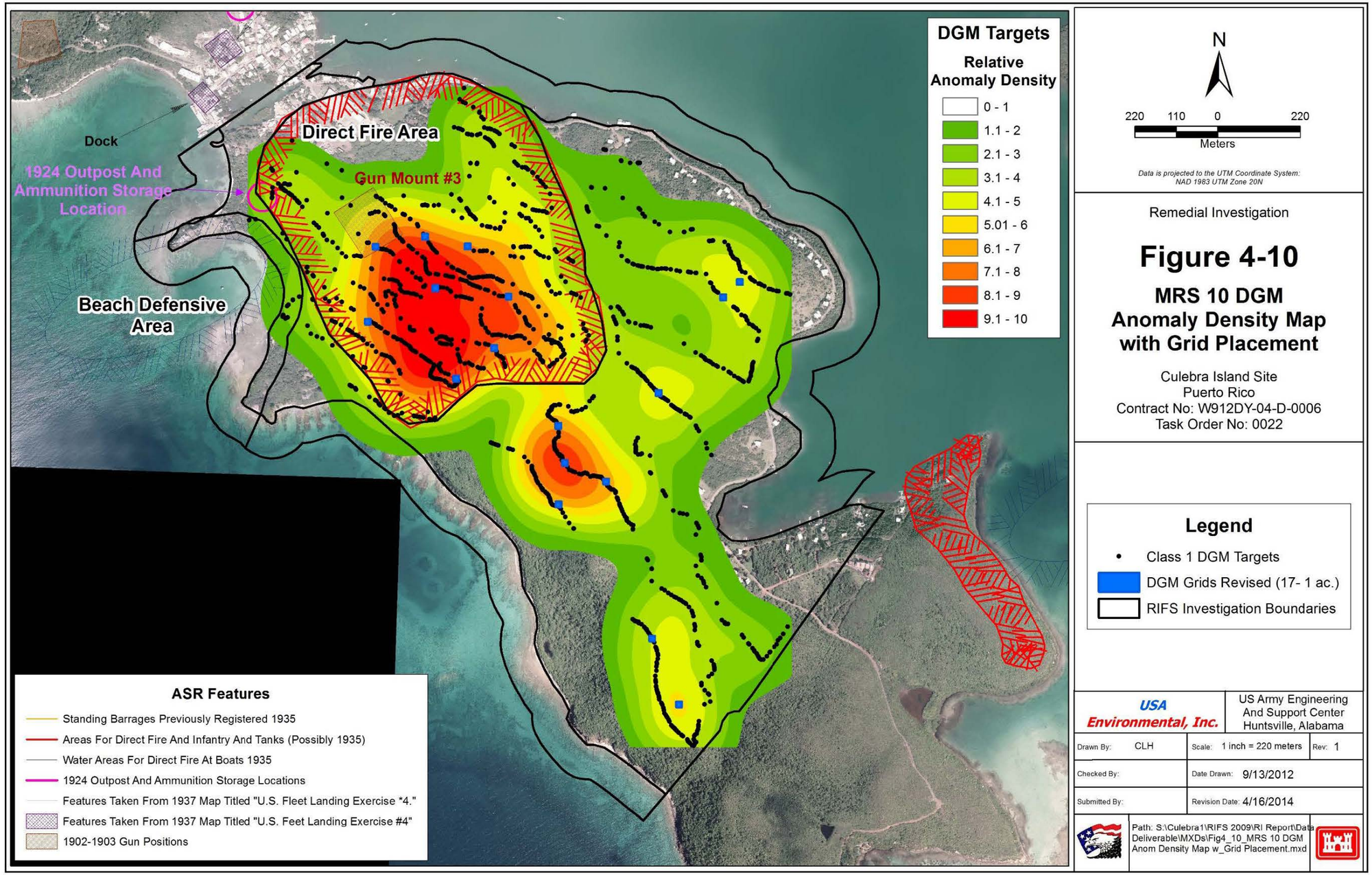

Figure 4-10: MRS 10 DGM Anomaly Density Map with Grid Placement

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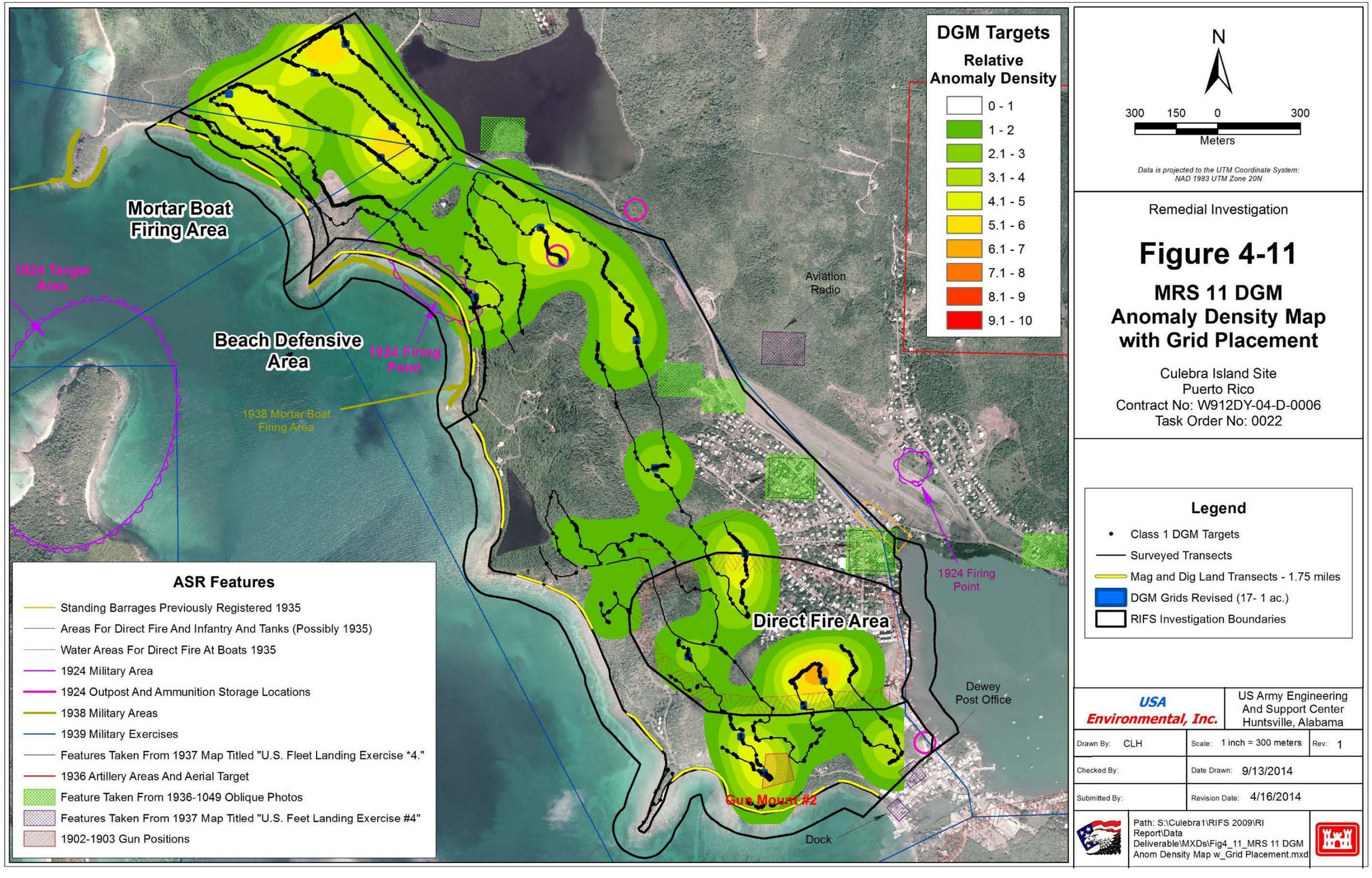

Figure 4-11: MRS 11 DGM Anomaly Density Map with Grid Placement

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Grid locations were selected with one grid near the center or peak of the high density areas to provide information for removal action cost estimates. Other grids overlapping the edges of the high density area were used to better document the MEC extent at each high density area. DGM grid (corner) locations were staked out using the Pro XRT with the external antenna mounted to a telescoping range pole, capable of extending 25 ft. Each grid area was surveyed by the field biologist to avoid all critical habitat and endangered species. Once a grid was established and accepted by the field biologist, it was devegetated in the same manner as transects, with the edges of each grid extended approximately 5 ft to allow the DGM sensor/operators to safely turn around. The cleared grid would then be seeded with a dynamic repeatability item (small ISO buried 3 to 7 times its diameter), and surveyed with the EM61-MK2, positioned with the Pro XRT, or traditional line, station, fiducials, if DGPS proved to be inadequate. Grid survey line spacing, necessary to reliably detect objects as small as a 37mm projectile were located every 2.5 ft. Grid coverage was 95% or greater at the 2.5 ft line spacing. All unavoidable obstacles in any grid were located with the Pro XRT and documented in the DGM maps. Grid anomalies were selected, as approved in the final GSV Report. DGM grid mapping resulted in 3,339 DGM anomalies. A total of 1,229 anomalies were selected for intrusive investigation between all six MRSs (Appendix J).

Dig lists and target maps for each DGM grid were provided to the USACE Geophysicist for review and approval. A recommended dig list of anomalies to intrusively investigate was created for each MRS. A decision was made by field teams to utilize the Whites DFX 300 All Metals Instrument in place of the EM61-MK2 as required by the approved WP. This decision was based on the re-growth of native vegetation along transects that had taken place to the degree it was compromising the team's ability to safely transport the EM61 equipment (stretcher-mode) into the grids. Because the DFX 300 instruments were smaller, it was easier to navigate within the excessive re-growth. This was not initially approved by USACE resulting in a corrective action (included in Appendix F); however, the overall intent was to remove the anomaly (not reach an acceptable mV reading) and the DFX 300 instruments were able to locate the anomalies without issue. All anomalies identified were flagged, excavated and removed. The investigation was not adversely impacted.

Photograph 4-3: DGM Transect Survey

4.1.4.2.4 Anomaly Reacquisition and Intrusive Investigations (Grids)

Reacquisition and intrusive investigations were conducted on selected grid locations proposed by USA and approved by the USAESCH Geophysicist. Grid anomalies are selected using the same selection threshold and classification criteria established during the GSV and documented in the GSV report. The selections were reviewed by the Project Geophysicist and the USAESCH Geophysicist. The Intrusive Investigations were conducted in accordance with the WP by two UXO qualified teams led by UXO Technician IIIs serving as Team Leaders. The SUXOS, UXOQCS and UXOSO provided oversight for safety and quality. Intrusive investigations were conducted in upland grids (DGM anomalies) and accessible beach areas (analog anomalies). All excavations were completed by hand using shovels. All anomalies on dry land were excavated to a depth necessary for recovery. Two anomalies in MRS 13 were just inside the low tide line in an area off limits to the investigation IAW the WP and were not recovered. Anomaly depths were generally shallow overall; varying from 0 to 18-inches in the upland areas to 2 to 24 inches in the beach areas, one beach anomaly was encountered at 40 inches. Intrusive investigation teams utilized personal digital assistants (PDAs) to record the intrusive results. Intrusive results were uploaded to the intrusive database and project GIS for analysis. A summary of the intrusive results is presented in Table 4-2. Documentation of the intrusive investigation, including tabulated intrusive results, is included in Appendix G. The field records for the intrusive investigations, including Site Manager's Daily Reports, Quality Control Daily Reports, and Safety Log, are presented in Appendix F.

As shown in Table 4-2, geological hot rock and non-munitions debris accounted for the majority of the recovered items. During vegetation removal, two MEC items were found on the surface at two locations in MRS 09: two Mk 25 marine flares. These flares were recovered on the surface along transects and not in the intrusive investigation grids, but are included in the results shown in the table. Munitions debris (MD), consisting of remnants of munitions, fuze parts, and expended small arms ammunition, was also recovered.

4.1.4.2.5 Analog Mag-and-Dig Transects

On the accessible beaches in each MRS and on accessible trails in MRS 13, intrusive teams used an analog sensor (White's DXF 300 All Metals Detector, which provided reliable results at the IVS) in the traditional Analog Mag-and-Dig mode, marking each anomaly with a plastic pin flag. During beach and beach buffer area transects, overlapping lines were used to cover each beach area 100%. All precautions necessary to avoid critical habitat or endangered species and to conduct safe boat operations were followed. Intrusive results were uploaded to the intrusive data base and project GIS for analysis. A summary of the intrusive results is presented in Table 4-2. Documentation of the intrusive investigation, including tabulated intrusive results, is included in Appendix G. The field records for the intrusive investigations, including Site Manager's Daily Reports, Quality Control Daily Reports, and Safety Log, are presented in Appendix F.

4.1.4.2.6 Surface Visual Reconnaissance Transects in MRS 13

The analog mag-and-dig investigation of the trails and beach areas in MRS 13 was augmented with a surface visual reconnaissance investigation conducted during a post award site visit. The investigation occurred as directed, primarily on trail areas cleared by the team (Figure 5-6). This investigation was conducted without an ESP in place and the observations of the items were visual; the items were not handled and were left in place. These areas investigated by visual

reconnaissance were not established/accessible trails and per the DQO for MRS 13 were not surveyed.

Photograph 4-4: Beach Analog Mag-and-Dig Investigations

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1793 **Table 4-2: Summary of RI Intrusive Investigation Results**

Investigation Type/MRS	Number of Locations						
	MEC	MD	Small Arms[1]	Other Debris	Hot Rock	Seed Items	Total
DGM Anomalies							
MRS 06	0	4	0	74	310	17	405
MRS 08	0	12	0	1	201	8	222
MRS 09	0	8	0	21	205	14	248
MRS 10	0	0	0	30	161	14	205
MRS 11	0	15	0	44	104	15	178
MRS 13	-	-	-	-	-	-	-
Analog Anomalies							
MRS 06	0	0	0	44	0	14	58
MRS 08	0	0	0	26	0	1	27
MRS09	2	0	0	20	0	4	26
MRS 10	0	0	0	35	0	6	41
MRS 11	0	2	0	38	0	24	64
MRS 13	0	10	2	304	72	20	408
Total	**2**	**51**	**2**	**637**	**1,053**	**137**	**1,882**

1794 [1]-Small Arms Ammunition

1795 Note: For MRS 13, the geophysical investigation was augmented with visual findings from surface reconnaissance
1796 conducted as part of a post award site visit in 2009. Those findings included MD from: 105mm projectiles
1797 (1-HE, 1-illumination, 4-unidentified), 5-inch projectiles (31), 3-inch projectiles (3), flares (8), fuzes, and other
1798 MD pieces.

1799 4.1.4.2.7 Geophysical and Intrusive Investigation Quality Control

1800 A comprehensive DGM Quality Control program was followed during production DGM. Daily
1801 instrument checks included:

1802 - DGPS checks at IVS Seed Item #2 location
1803 - Morning and Afternoon IVS checks
1804 - Morning and Afternoon Static checks

1805 Production DGM performance metrics were determined for the fllowing:

1806 - Production Transect and Grid Along Line Sample Separation
1807 - Grid Internal Consistency (proper length and/or diagonal)
1808 - Grid coverage
1809 - Grid BSI detection

DGM QC results are delivered in the DGM ACCESS Database, included in Appendix J, along with the DGM data.

Analog geophysics Quality Control included the following:

- Daily Analog system (sensor and operator) daily checks
- Daily Geodetic DGPS Functionality check
- Analog Coverage Seeds
- Analog BSIs
- Analog Intrusive Acceptance Sampling

Analog QC results are delivered in the Analog ACCESS Database, included in Appendix J. Both the DGM and Analog Access databases were updated daily and delivered to the USACE QA Geophysicist weekly for their review and comment.

During the intrusive investigation activities the UXOQCS installed blind seed items (BSIs) in all DGM grids and beach analog areas, following standard anomaly avoidance procedures. BSIs were not installed along transects, as no intrusive operations were planned along them. Transect data was used to develop anomaly density maps which helped place DGM grids to determine the nature and extent of potential MEC contamination in each high density area. The small ISOs (37mm projectile simulant) were used as BSIs and were buried at depths between 3.9 in. (3 x dia.) and 9.2 in. (7 x dia.) measured from ground surface to item center and a variety of orientations. The range of small ISO responses at the IVS was used to establish the expected range of BSI responses in production DGM grids.

The UXOQCS verified anomaly resolution of both the DGM and analog digs based on the allocation of investigations by MRS (Acceptance Sampling). The UXOQCS utilized the established criteria in the Work Plan for the number of intrusive investigations allocated for DGM and analog, and the number of QC checks required for both to achieve a 70% confidence that there are <10% unresolved anomalies if MEC is detected and a 90% confidence that there are <5% unresolved anomalies if no MEC is detected as prescribed in the PWS, Tables 7-1 and 7-2. The number of QC checks in the Work Plan was based on the calculations in Table 7-3 of the PWS, Acceptance Sampling Table for Anomaly Resolution. No QC failures were recorded during the RI. Quality Control Reports are included in Appendix F.

4.1.5 Munitions Management

4.1.5.1 MEC Identification and Disposal

No MEC items were recovered during intrusive investigations. However, two Mk 25 Marine Marker flares were discovered on the surface by UXO Technicians while conducting vegetation removal activities in MRS 09. These items were deemed acceptable to move by the SUXOS and UXOSO and were disposed of by a demolition shot on 26 May 2011. The demolition event was located within MRS 09. The two Mk 25 Marine Markers were the only MEC items recovered during the RI fieldwork. The two MEC items were recorded in the project MEC log accompanied by photographs (Appendix H). The only other item recovered was a partial BDU-33 that was discovered during beach intrusive on MRS 13. This item was classified as Material Potentially Presenting an Explosive Hazard (MPPEH) and deemed safe to move by the SUXOS

and UXOSO and, with approval by the onsite USACE OESS, was transferred to MRS 09 to the same location as the two Mk 25 Marine Markers. A disposal event was conducted on 13 June 2011 where the BDU-33 was subsequently reclassified as Material Documented as Safe (MDAS). Two separate demolition/disposal events were conducted each at the same location in accordance with the Explosives Siting Plan (ESP), WP, and the demolition SOP. Prior to each demolition event, 24 to 36 hours' notice was provided in writing to the Federal Aviation Administration (FAA), USCG, fire/police, and other local stakeholders. The demolition location is shown on Figure 5-3. Copies of the demolition notices are included in Appendix D. A summary of the two demolition activities is shown on Table 4-3.

Table 4-3: Summary of Demolition Activities

Date	Location	Shot Time	Time Cleared	Munitions Destroyed
26 May 2011	MRS 09	15:30 local	16:00 local	(2) Mk 25 Marine Markers
13 June 2011	MRS 09	10:30 local	11:00 local	(1) partial BDU-33

All MD recovered from investigation and after demolition was inspected by the SUXOS, re-inspected by the UXOQCS, certified as MDAS, and documented on Form 1348 found in Appendix A. The MDAS was drummed, sealed and locked in secure storage until it was shipped offsite to TES for disposal, in a form where it could only be identified by its basic content. TES issued a Certificate of Destruction (COD), a copy of which has been provided in Appendix A.

Photograph 4-5: Disposal of MEC Items in MRS 09

4.2 MC Characterization

4.2.1 General

This section provides details of the approach, methods, and operational procedures used for the sampling and analysis activities conducted for the characterization of MC at the Culebra Island MRSs. An MC Sampling and Analysis Plan (SAP), comprised of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP) describing the sampling to be conducted during the RI was included with the WP and updated in October 2011 and November 2013.

4.2.2 MC Sampling Field Activities

Past military training activities at the Culebra Island MRSs may have resulted in the presence of MC contamination in areas where training may have occurred. These activities included sea-to-shore ranges, air-to-ground ranges, ground-based munitions, and aerial bombing targets. To determine whether chemical constituents associated with past training activities pose a risk to human health and the environment, a sampling and analysis program was conducted for existence of MC associated with historic munitions use at the site. An MC SAP was prepared to meet these objectives; the SAP was presented in Appendix E of the WP and described the sampling efforts to be conducted during the RI.

4.2.3 Purpose of MC Sampling Activities

An objective of the RI, as established during the TPP process, was to assess risk to human and ecological receptors due to the potential presence of MC in the soil, sediment, and surface water within the former Culebra Island MRSs and characterize impacts to these media at MEC and MD locations within the MRSs. The SAP was implemented to plan the collection of environmental data and assure that the quality of the data meets the needs of the end user. The sampling program achieves the sampling and analysis component of the PWS dated June 16, 2009. These objectives are:

- To characterize the nature and extent of MC, if present, and
- To provide sufficient information to assess risk, if any, to human health and the environment.

To achieve these objectives, environmental samples (i.e., soil, sediment, surface water) were collected based on recommendations presented in the Site Inspection Report (Parsons, 2007), from decisions made during the TPP meeting, and from locations where MEC might be encountered during the intrusive operations within the MRS. Groundwater samples were collected based on results of a Well Survey conducted in 2013. All samples were collected in accordance with the project SAP. Sample locations and concentrations exceeding human health screening levels and ecological screening levels are described in further detail in the following paragraphs.

4.2.4 Sampling Rationale

Based on the CSM and DQOs for the Culebra Island MRSs, MC would be released to the environment only as a result of munitions-related activities that would have occurred in the various MRSs. If there was no evidence of munitions-related activities in a given area (e.g.,

MEC, MD/frag, target berms, ground scars), then there was no reason to expect that MC would have been released in that area. Therefore, the MC sampling effort focused on determining the presence of MC contamination associated with evidence of munitions-related activities. In areas with no evidence of munitions-related activities, no sampling was conducted. The sampling rationale for each MRS is summarized below.

In September 2013 a well survey was conducted to evaluate existing wells for groundwater sampling, and the potential need for well installation. The results of the well survey are reported in the Groundwater Letter Report found in Appendix N. No evidence was found of the aquifer being used as a potable water supply. The conclusion of the Letter Report was there are no existing wells that would deliver relevant results to evaluate DoD impacts to the island. Of all the wells surveyed, only two wells were identified as suitable for sampling, both were located in MRS 06. One was in the general vicinity of low densities of MD findings, the other was in the vicinity of an area identified as a land impact area. Two wells were installed, one in MRS 09 and one in MRS 11. Both MRSs had very low densities of MD findings. No MEC or MD were found in MRS 10. Therefore, no groundwater evaluation was conducted.

4.2.4.1 MRS 06

MD was found in three of the DGM grids located in this MRS. Four MD items were found between three grids (06-03, 06-07 and 06-17). All MD was found on the surface. The other remaining grids contained no MD items. Based on the CSM, and the proposed MC release mechanism, areas with higher MEC/MD anomaly densities were expected to have the greatest potential to release MC to the environment. Grids 06-03, 06-07 and 06-17 were expected to have a lower potential of MC contamination than the grids with 4 or more MD items, due to the lower MD densities observed during the geophysical and intrusive investigations. Therefore, one sample was collected from a random location within each of these grids. All samples were collected from 0 to 6 inches bgs or until bedrock was encountered. All samples were analyzed for explosives and MC metals in accordance with the 2011 MC QAPP refined with results from the MEC investigation, and updated in November 2013 to include a groundwater investigation.

Of 11 wells identified in MRS 06, only two existing wells (6-6 and 6-9) were suitable for groundwater sampling. Wells were considered suitable if a ROE was obtained, the well was used for appropriate reasons (i.e, not for sewage), the well is under control of the owner, and the well is closed to the elements (not a large diameter well exposed to contamination by other factors). One well, 6-9, was in the general vicinity of MD findings and the 1924 Firing Point. Well 6-6 was not in the vicinity of any MD identified in the RI, but was in an area identified from historical data as a Land Impact Area.

4.2.4.2 MRS 08

MD was found in six of the DGM grids located in this MRS. Four MD items were found in both grids 08-02 and 08-03. The other four grids contained two or fewer MD items. MD was found in depths ranging from surface to 3 inches. Based on the CSM, and the proposed MC release mechanism, areas with higher MEC/MD anomaly densities were expected to have the greatest potential to release MC to the environment. Therefore, more samples were collected from grids 08-02 and 08-03, because these grids would most likely exhibit MC contamination, if present. Therefore, these grids were divided into quadrants of equal size, with one sample collected from a random location within each quadrant. The remaining grids (08-06, 08-07, 08-08, and 08-09)

were expected to have a lower potential of MC contamination. Therefore, one sample was collected from a random location within each of these grids. All samples were collected from 0 to 6 inches bgs or until bedrock was encountered. All samples were analyzed for explosives and MC metals in accordance with the SAP.

This MRS was excluded from the groundwater evaluation due to an incomplete pathway.

4.2.4.3 MRS 09

MD was found in three of the DGM grids located in this MRS. Four MD items were found in grid 9-13. The other two grids contained two or fewer MD items. MD was found in depths ranging from the surface to 4 inches. Based on the CSM, and the proposed MC release mechanism, areas with higher MEC/MD anomaly densities were expected to have the greatest potential to release MC to the environment. Therefore, more samples were collected from grid 9-13, because this grid would most likely exhibit MC contamination, if present. Therefore, this grid was divided into equal sized quadrants, with one sample collected from a random location within each quadrant. The remaining grids (9-04 and 9-07) were expected to have a lower potential of MC contamination. Therefore, one sample was collected from a random location within each of these grids. All samples were collected from 0 to 6 inches bgs or until bedrock was encountered. All samples were analyzed for explosives and MC metals in accordance with the FSP and QAPP. In addition, three surface water and two sediment samples were collected in the lagoon downstream from grids 09-04 and 09-07.

Of the 2 existing wells identified in MRS 09, neither was identified as suitable for sampling. One well was a large diameter well open to the elements and susceptible to contamination from non-DoD factors. The other well was submerged in a lagoon. Therefore, one well was installed in this MRS in the general vicinity of RI MD findings. The well location was changed from the original location selected due to development in the area. The location was in the vicinity of multiple targets, the Water Target in Sueno Cove, and an area that could receive over fire from the Mortar Boat Firing Area. The well was placed in an area downhill from the low densities of MD findings. The well depth was 30 feet and depth to groundwater at time of sampling was 21.4 feet. The well was screened from 10 to 30 feet bgs.

4.2.4.4 MRS 10

Although this was an area identified as a Direct Fire Area, there was no evidence of munitions-related activities in the 16 DGM grids places throughout the MRS or along the beach analog mag-and-dig transects evaluated at this MRS. There is no historical evidence of MEC or MD found in this area. Field activities did not reveal evidence of metallic (target) debris or range features, there is no reason to suspect that the site was a concentrated munitions use area and sampling would not be justified based on the DQOs. Therefore, IAW the work plan no MC sampling was conducted.

4.2.4.5 MRS 11

Similar to MRS 13, there were two beach areas that exhibited evidence of munitions-related activities in the form of MD/frag found along the beach during the MEC investigation. MD was found in depths ranging from surface to 3 inches. These beaches are accessible to recreational users who may travel to the island. Therefore, MC sampling of these beaches was conducted to

determine if there is evidence of a release of MC to soil at these beaches. Since it is expected that recreational users can be exposed to soil (sand) randomly at each of the beaches, a stratified random sampling approach was implemented for each of the beaches. Sample locations are shown on Figure 4-17. The beach sampling was focused in areas of MEC findings along the transects. The area of the transect where MEC was found was divided into eight equally sized segments. One sample was collected from a random location within each segment. Because of the dynamic nature of the beach sand, the samples were collected from a depth of 0 to 12 inches bgs. All samples were analyzed for explosives and MC metals in accordance with the FSP and QAPP.

In addition to the beach areas, MD was found in six of the DGM grids located at the northern portion of the MRS. Six MD items were found in grid 11-13 and three MD items were found in grid 11-15. The rest of the grids contained two or fewer MD items. MD was found in depths ranging from surface to 4 inches. Based on the CSM, and the proposed MC release mechanism, areas with higher MEC/MD anomaly densities would be expected to have the greatest potential to release MC to the environment. Therefore, more samples were collected from grids 11-13 and 11-15, because these grids would most likely exhibit MC contamination, if present. Therefore, each of these grids was divided into equal sized quadrants, with one sample collected from a random location within each quadrant. The remaining grids (11-12, 11-14, 11-16, and 11-17) were expected to have a lower potential of MC contamination. Therefore, one sample was collected from a random location within each of these grids. All samples were collected from a maximum depth of 0 to 6 inches bgs or until bedrock was encountered. All samples were analyzed for explosives and MC metals in accordance with the FSP and QAPP.

Of 15 wells evaluated in MRS 11, no wells were suitable for sampling. One identified well was broken off, and one suspected as present was not present. Therefore, one well was installed in this MRS away from the landfill leachate and influences from development. The well was placed in an area downhill from MD findings. The well depth was 40 feet and depth to groundwater at time of sampling was 18.25 feet. The well was screened from 20 to 40 feet bgs.

4.2.4.6 MRS 13

The RI investigation identified evidence of munitions-related activities (MD only, no MEC) at four beaches on Cayo Louis Pena. Most MD items were found in depths ranging from surface to 12 inches, two items were found in coarse pebbly sand composed primarily of broken shells from depths of 18 and 30 inches. These beaches are accessible to recreational users who may travel to the island. Therefore, MC sampling of these beaches was conducted to determine if there is evidence of a release of MC to soil at these beaches. Since it is expected that recreational users can be exposed to soil (sand) randomly at each of the beaches, a stratified random sampling approach was proposed for each of the beaches. The beach sampling was focused in areas of MEC findings along the transects. The area of the transect where MEC was found was divided into eight equally sized segments. Each beach area (as identified by the length of the transects that were conducted during the MEC investigation) were divided into eight equally sized segments. One sample was collected from a random location within each segment. Because of the dynamic nature of the beach sand, the samples were collected from a depth of 0 to 12 inches bgs. All samples were analyzed for explosives and MC metals in accordance with the SAP.

This MRS was excluded from the groundwater evaluation due to a incomplete pathway. The groundwater is not used as a potable water supply.

4.2.5 Sampling Locations

The DQO for MC characterization was developed through the TPP process. Parameters for sampling locations were as follows.

- Surface and subsurface soil sampling locations established based on locations of MEC/MD discovered during the geophysical investigation.
- Surface water and sediment samples will be collected from down gradient streams and depositional areas down gradient from areas containing MEC/MD discovered during the geophysical investigation.
- Groundwater samples collected from wells identified in the Well Survey and any installed wells at locations of suspected DoD impacts.

The following paragraphs summarize the sampling locations for each Culebra Island MRS.

4.2.5.1 Background Sample Locations

Forty-five background surface soil samples were collected from nine soil types (five samples per soil type) across Culebra Island that were not affected by historic DoD activities. The samples were collected from surface soil (0-2 inches bgs). Historical documentation was reviewed and samples were collected at locations where munitions use was unlikely (i.e. cantonment areas). All areas were screened to make sure no MEC or MD was found in the vicinity. Background sampling locations were paired to the respective soil map units as from the U.S. Department of Agriculture (USDA) soils map for Culebra (Puerto Rico, Humacao Area, Puerto Rico Eastern Part -PR689, Version 3, August 19, 2008). Five samples were collected at each location, four samples collected at ordinal locations 10 feet from a center sample.

Three background surface water samples were collected from the banks of Cornello Lagoon, an area where historical documentation indicated was likely not affected by DoD activities. No background sediment samples were collected due to the coarse nature of the media present. No background groundwater samples were collected.

Background sample locations are presented on Figure 4-15.

4.2.5.2 MRS 06 Sampling Locations

A total of 17 surface soil samples were collected in MRS 06. Per the DQO for sampling locations, three locations corresponding to MD presence were sampled for soil (Grids 06-03, 06-07 and 06-17). A barium exceedance at Grid 06-17 resulted in the collection of 13 step-out samples (plus one field duplicate) to define the extent of the exceedances.

Two groundwater samples were collected from suitable existing wells in the MRS. Well 6-6 was located in the center of the MRS, well 6-9 in the vicinity of DoD activity. Figure 4-16 and Figure 4-17 present the sampling locations in MRS 06.

4.2.5.3 MRS 08 Sampling Locations

Per the DQO for sampling locations, six locations corresponding to MD presence were sampled for soil (Grids 08-02, 08-03, 08-06, 08-07, 08-08, and 08-09). Four surface soil samples were collected from Grids 08-02 and 08-03 since they contained the greatest amount of MD. One

surface soil sample was collected in each of the other four grids. Figure 4-18 presents the sampling locations in MRS 08. This MRS was excluded from the groundwater investigation.

4.2.5.4 MRS 09 Sampling Locations

Per the DQO for sampling locations, four locations corresponding to MD presence were sampled for soil (Grids 09-04, 09-07, and 09-13). Four soil samples were collected from Grid 09-13 since it contained the greatest amount of MD. One soil sample was collected in each of the other two grids. Three sets of sediment and surface water samples were collected from a lagoon located behind Sueno Cove. One groundwater sample was collected from a well installed in the vicinity of a grid with MD findings near Soldado Point. Figure 4-19 presents the sampling locations in MRS 09.

4.2.5.5 MRS 10 Sampling Locations

Per the DQO for sampling locations, no samples were collected as no MEC or MD were recovered during the geophysical investigations.

4.2.5.6 MRS 11 Sampling Locations

Per the DQO for sampling locations, eight locations corresponding to MD presence were sampled for soil (Grids 11-12, 11-13, 11-14, 11-15, 11-16, and 11-17; and Beach Transects 11M-08 and 11M-11). Four soil samples were collected from Grids 11-13 and 11-15 since they contained the greatest amount of MD. One soil sample was collected in each of the other four grids. Eight soil samples were collected along both Beach Transects 11M-08 and 11M-1. One groundwater sample was collected from a well installed downhill from MD findings away from contamination from non-DoD sources.

Figure 4-20 presents the sampling locations in MRS 11.

4.2.5.7 MRS 13 Sampling Locations

Per the DQO for sampling locations, four locations corresponding to MD presence were sampled for soil (Beach Transects 13M-21, 13M-22, 13M-18, and 13M-09). Eight soil samples were collected along each Beach Transect. This MRS was excluded from the groundwater investigation due to an incomplete pathway.

Figure 4-21 presents the sampling locations in MRS 13.

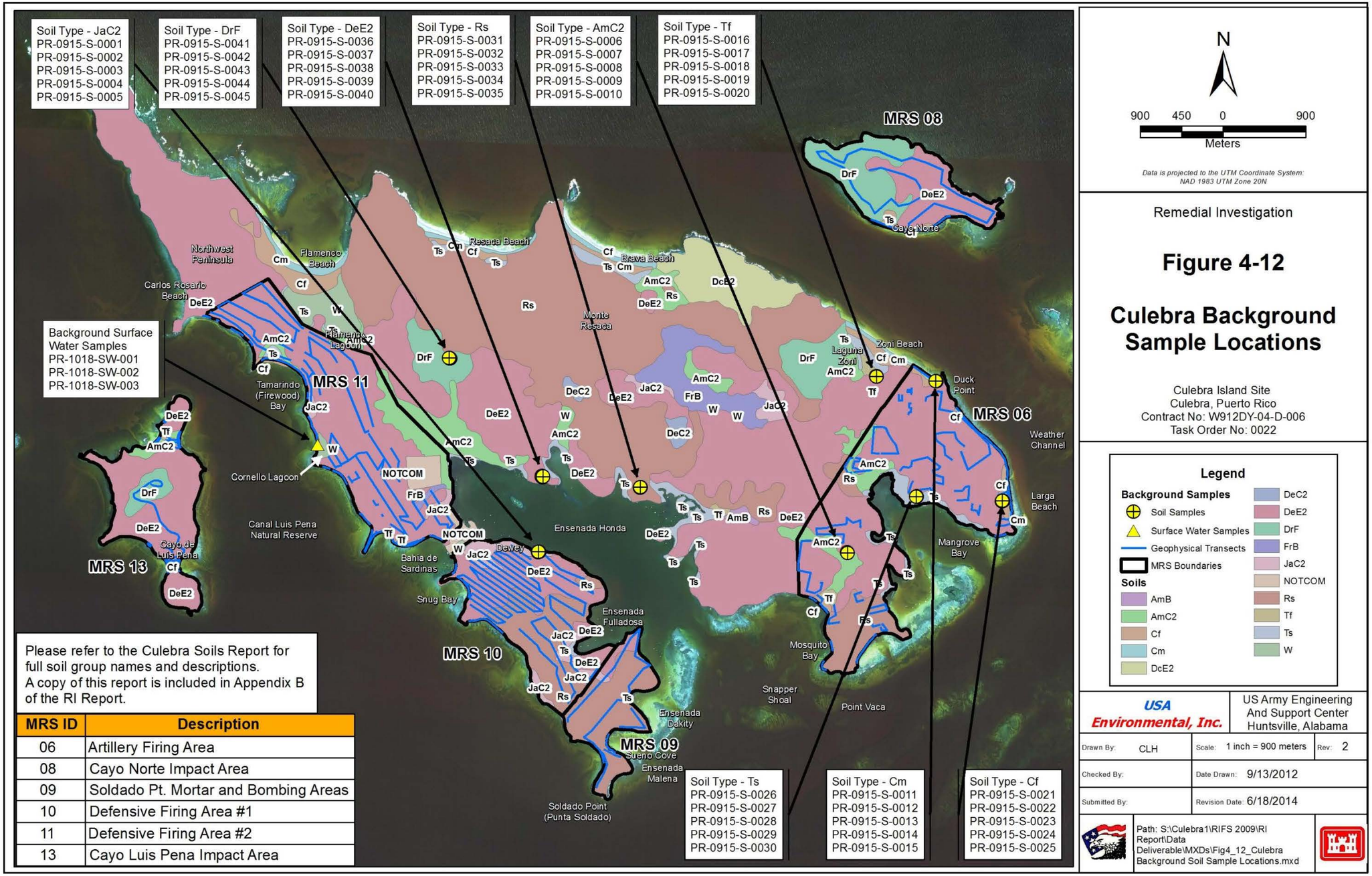

Figure 4-12: Background Sample Locations

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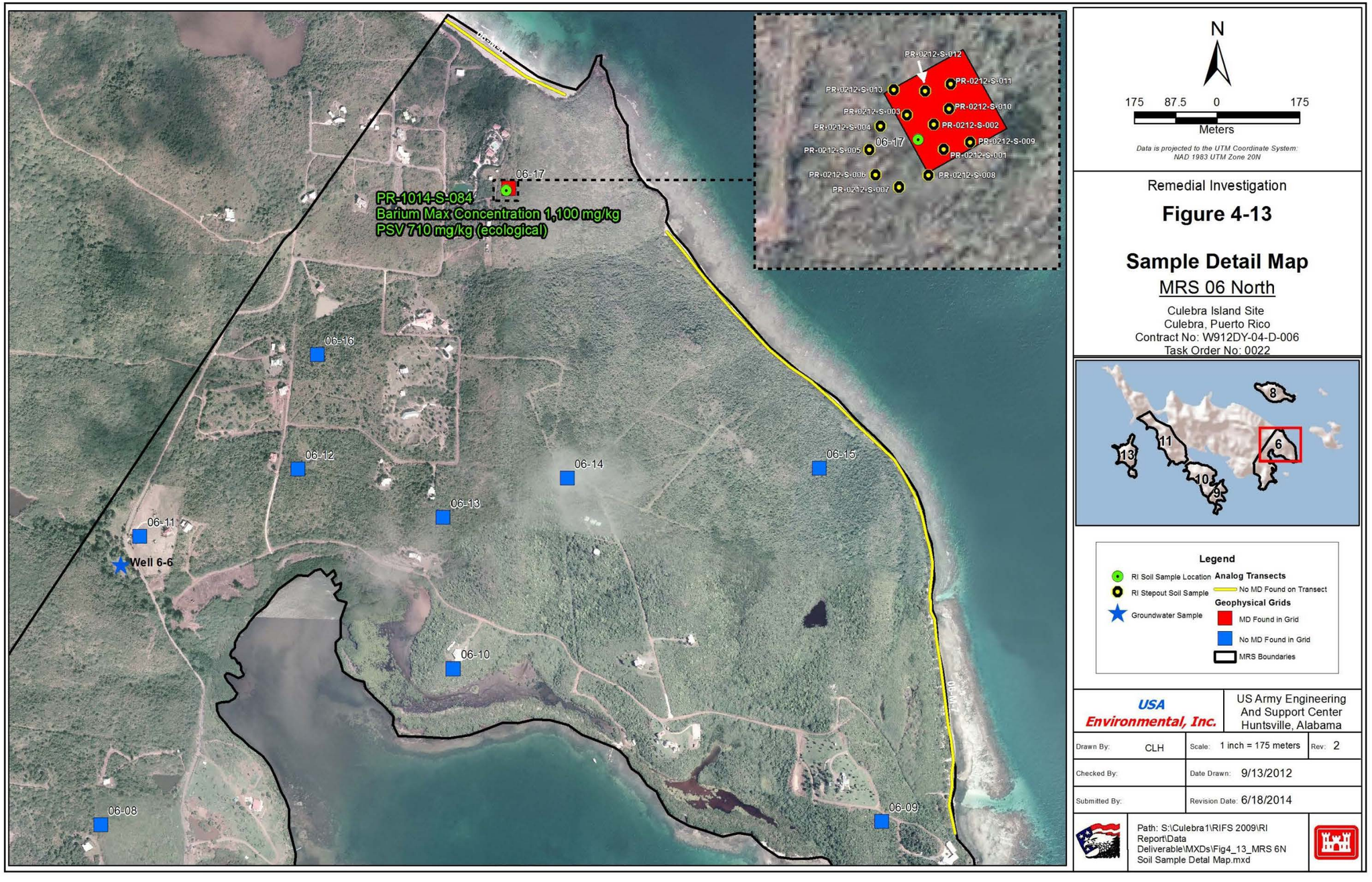

Figure 4-13: MRS 06 MC Sampling Locations (North)

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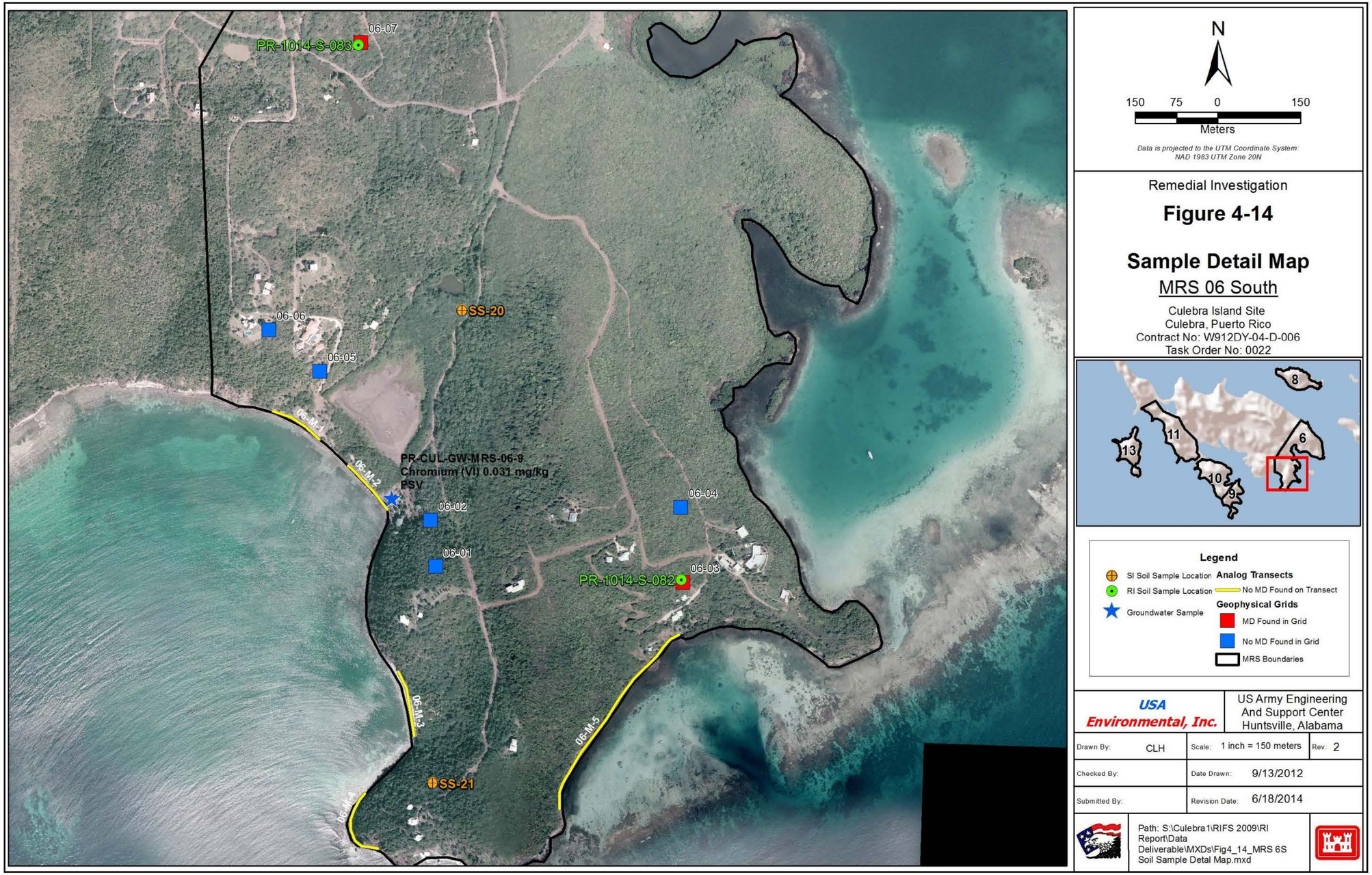

Figure 4-14: MRS 06 MC Sampling Locations (South)

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Figure 4-15: MRS 08 MC Sampling Locations

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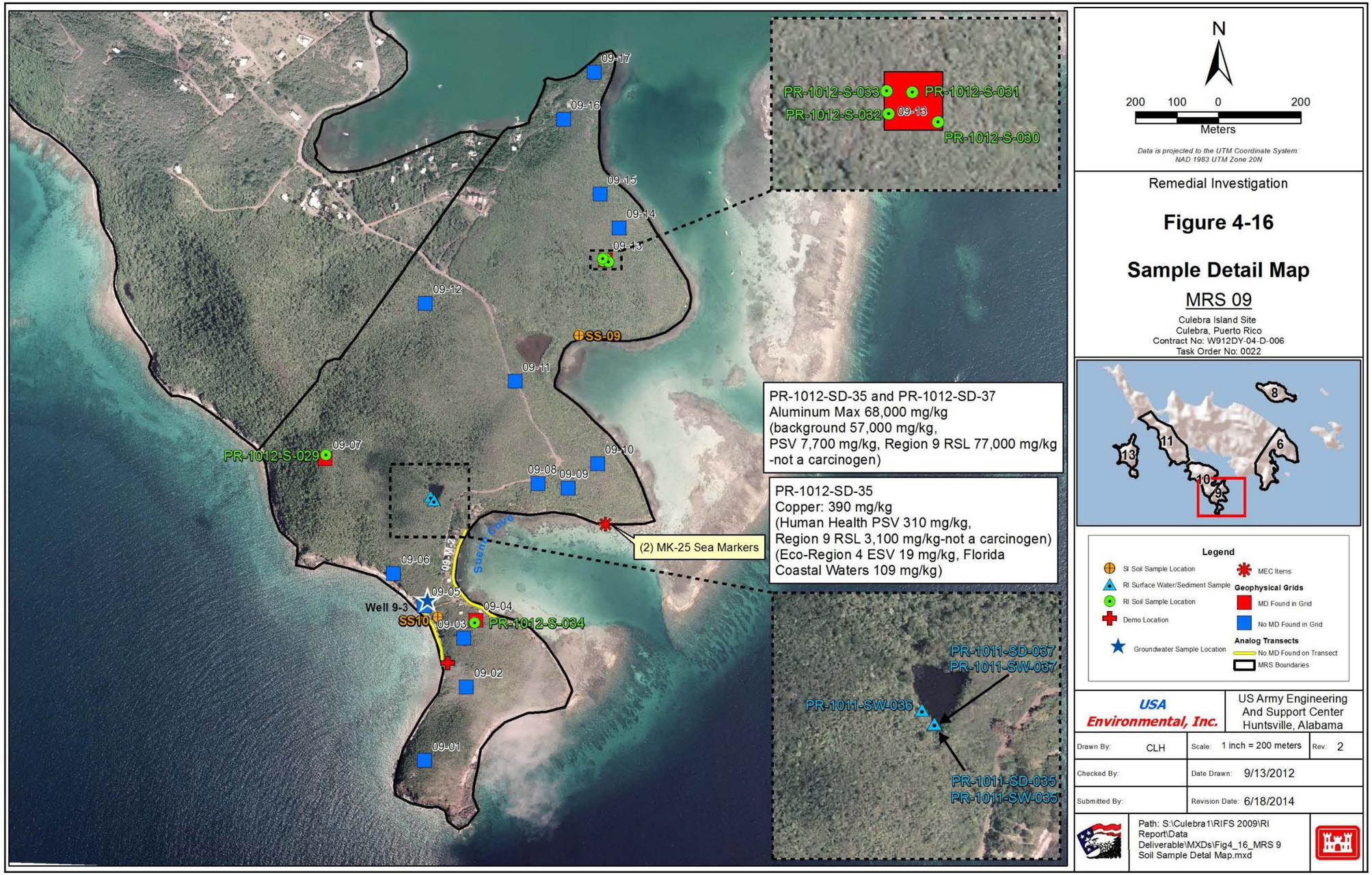

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2123 **Figure 4-16: MRS 09 MC Sampling Locations**

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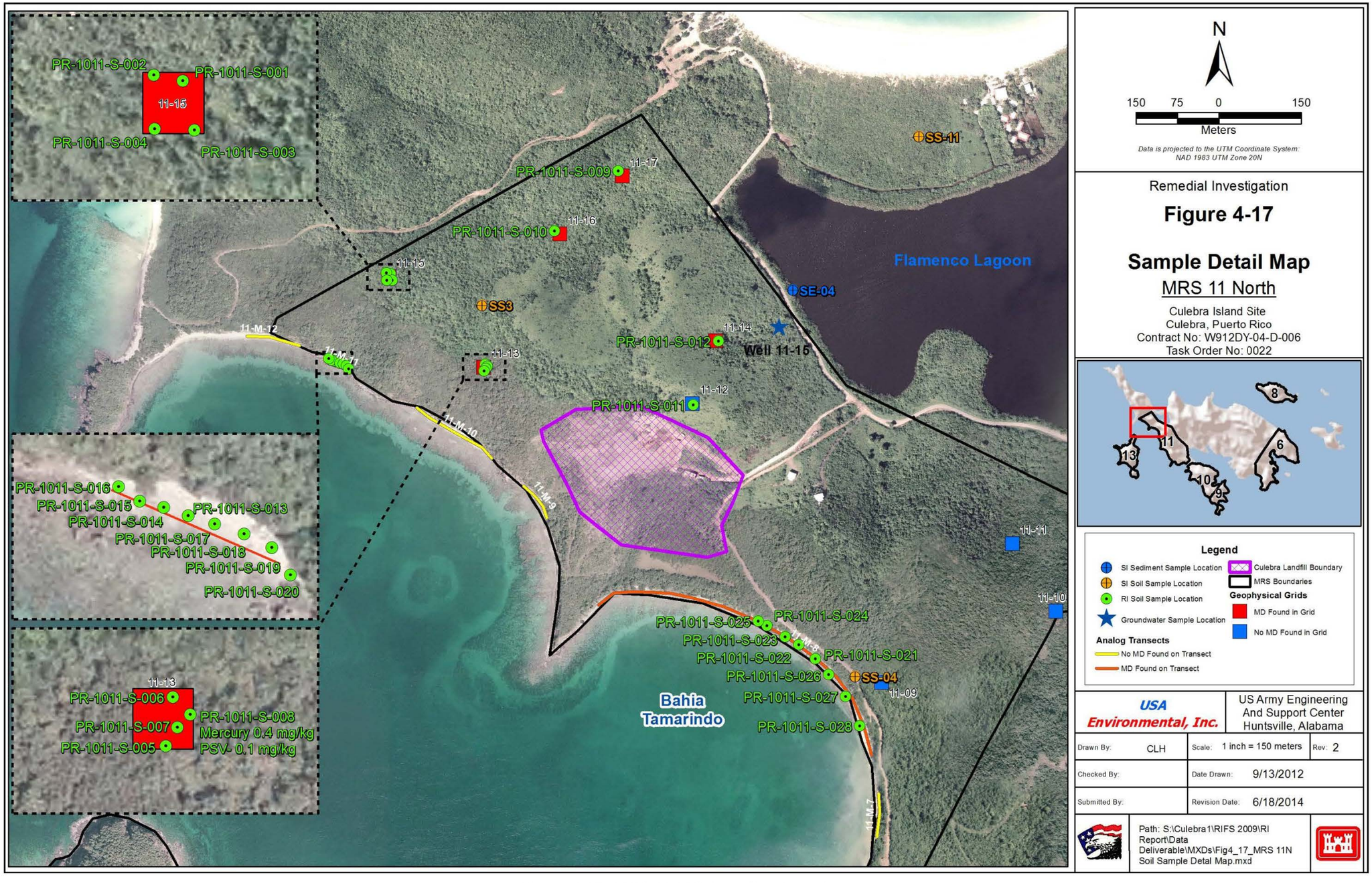

Figure 4-17: MRS 11 MC Sampling Locations

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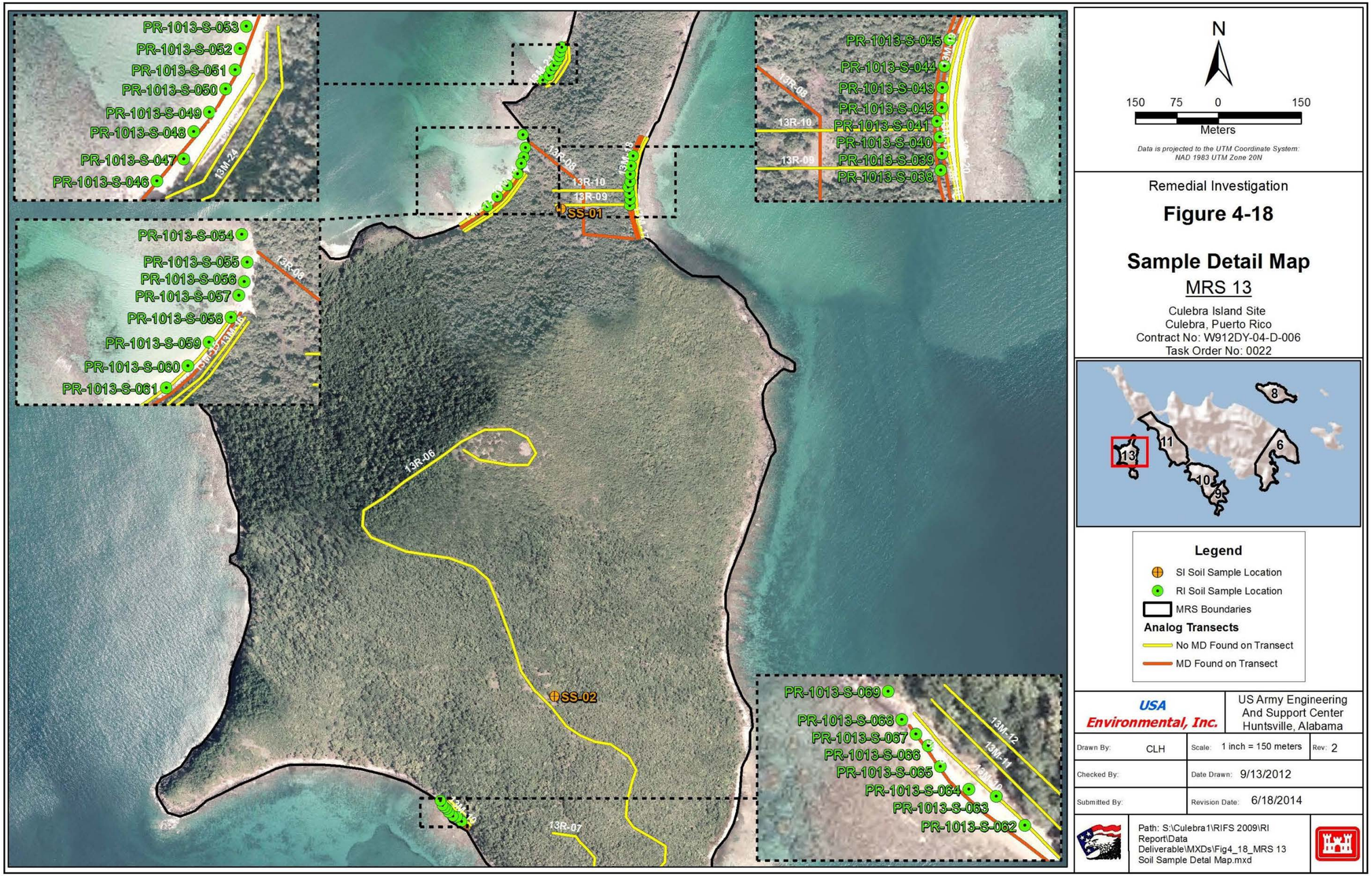

Figure 4-18: MRS 13 MC Sampling Locations

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4.2.6 Field Sampling Activities

Subsequent to completing Intrusive Investigations within each MRS, an environmental sampling team collected soil, surface water, and sediment samples per the DQOs and Field Sampling Plan (FSP) and QAPP found in Appendix E. Groundwater sampling was conducted in December 2013 as part of the groundwater evaluation later added to the investigation. Only wells located within the MRSs covered by this contract were evaluated in the groundwater investigation. Due to the predominantly shallow soil profiles on Culebra (< 12-inches, on average), only surface soil samples were feasible. Although anomaly depths varied to 18 inches in the upland rocky areas, no MEC or MD was found below 3 inches in these areas, therefore, subsurface sampling was not conducted. In the beach areas, per the QAPP refined in October 2011 to reflect results from the MEC investigation, soil samples were collected from 0 to 12 inches, due to the dynamic nature of beach environments. All MD was found within this depth interval except for two items collected at depths of 18 to 40 inches. The beach conditions in these areas were comprised of large (coarse) pieces of broken coral and shells and were not adequate media for sampling. Surface water and sediment samples were collected only in terrestrial water bodies down gradient from investigation grids containing MEC or MD. MRS 09 was the only area that required surface water and sediment sampling per the DQO. Anomaly avoidance was performed at sample locations using a White's DXF 399 All Metals Detector.

Initial plans called for use of the Innov-X metal detector. However, the Innov-X was not useable at the site and was replaced with additional step-out samples in areas that indicated PSV exceedances.

The TPP Team for the 2007 SI agreed that because groundwater is used for consumption on Culebra Island, groundwater sampling would not be conducted during the 2007 SI phase, and groundwater would be further evaluated during a subsequent RI/FS if a complete pathway was identified during the 2007 SI. The 2007 SI found no identifiable receptors that could result in a complete exposure pathway for MC via groundwater use. During research for the 2007 SI, three documents on groundwater usage were identified. A 1995 study, Water Wells on Isla de Culebra, Puerto Rico, listed 77 wells on the island of Culebra, of which only 16 were being used for any purpose (Cherry, 1995). The report states that well water from 10 wells was being used to flush toilets, water and clean horses, water livestock, and water plants. The remaining six wells were listed as being owned by the Puerto Rico Aqueduct and Sewer Authority (PRASA); however, only two were listed as being pumped, and no information was provided about the use of this water (Parsons, 2007).

The second report, *Puerto Rico Water Use Program: Public-Supply Water Use and Wastewater Disposal During 1990*, shows the rate of withdrawal in millions of gallons per day as zero for Culebra (as cited in Veve and Taggart, 1996). The assertion that groundwater is not used as a source of drinking water on Culebra Island is further supported by the third report, *Estimated Water Use in Puerto Rico, 2000* (Molina-Rivera, 2000). This USGS open file report was prepared in cooperation with PRASA and concluded that in 2000, no water was being withdrawn for public-supply water systems or for domestic self-supplied use on Isla de Vieques and Culebra (Parsons, 2007).

A groundwater survey was conducted in 2013 to evaluate wells referenced in the 1995 Cherry report and any newly installed wells. The full results from this well survey are presented in a Letter Report located in Appendix N. Two wells were identified as suitable for sampling, both

located in MRS 06. Well suitability was based on a variety of factors, the first of which included protection of the well from the elements (many wells were very large diameter wells ranging from two to 18 feet in diameter and open to the elements and non-DoD sources of contamination). Other factors considered for exclusion of wells include use of the well for sewage disposal, location of the well down gradient from the landfill, a well covered by landfill expansion, locaton of the well in an a chicken coop, a well that was broken, unuseable, or sealed off, a well submerged in a lagoon, or a well location for which ROE was not obtained. The wells were located using the coordinates from the Cherry Report (which per Mr. Cherry were very general and not accurate) and interviews with residents and the municipality. Two wells were installed and sampled, one in MRS 09 and one in MRS 11. No wells were identified as drinking water wells.

Sampling containers and shipping coolers were provided by the laboratories and contained the proper preservatives as specified in the SAP. The sampling team utilized a drop freezer set at the prescribed temperature for sample storage. Groundwater and IDW samples were kept on ice in coolers. One temperature blank was included in each cooler upon shipping. Sample shipments were manifested on a chain-of-custody (COC) form and were made weekly or as necessary to meet the extraction timeframes prescribed in the FSP and QAPP.

QA/QC, Field Duplicates, and Matrix Spike/ Matrix Spike Duplicate (MS/MSD) samples were collected in the frequencies specified in the FSP. These samples were shipped to the respective laboratories in the same manner as the primary samples.

4.2.6.1 Soil Sampling Procedures

Discrete surface soil sample (including discrete background soil samples) were collected from 0 to 6 inches bgs using a sampling spoon. For each sample the sampler donned a new pair of disposable latex or nitrile gloves and used only clean, decontaminated sampling equipment for sample collection. All vegetation and debris was removed from the sampling point prior to sampling and borings with the soil removed from the hole were backfilled following sample collection. Each discrete sample was placed into a stainless steel or Pyrex bowl, mixed and then quartered. Each quarter was allocated to a sample jar until the jar was full. Samples were stored in a drop freezer set at the temperatures specified in the FSP and QAPP. Samples were packaged in coolers and shipped to the laboratories weekly. The Innov-X metals detector was not used due to malfunction, and therefore, step out samples were collected at locations of PSV exceedances.

4.2.6.2 Surface Water and Sediment Sampling Procedures

For each surface water and sediment sample the sampler donned a new pair of disposable latex or nitrile gloves and used only clean, decontaminated sampling equipment for sample collection. Surface water sample collection locations were deep enough so that the sample bottles were able to be held upright during collection to avoid compromising the preservative. Downstream samples were collected first and disturbances during wading were avoided. The direction of sample collection started at the furthest downstream location and proceeded to the farthest upstream location. After the sample bottle was filled, the cap was placed on the bottle and the bottle was packaged for shipment. Samples were stored in a drop freezer set at the temperatures specified in the FSP and QAPP. Samples were packaged in coolers and shipped to the laboratories weekly.

The sediment samples were collected furthest from the source locations first, to minimize the possibility of cross-contamination. Thereafter, the most downstream sediment samples were collected followed by the next upstream samples, if required. If surface water samples were taken at the same location, they were collected before the sediment samples. The addition of organic matter into the sediment samples was avoided. While facing upstream, the sample was collected by scooping along the bottom of the surface water body with a decontaminated plastic scoop. Excess water was removed from the scoop and sediment sample was placed into a decontaminated stainless steel bowl. After a sufficient sample volume was collected into the stainless steel bowl, the sample was homogenized, quartered and placed into the appropriate sample jars. After a sample bottle was filled, the cap was placed on the bottle and the bottle was packaged for shipment. Samples were stored in a drop freezer set at the temperatures specified in the FSP and QAPP. Samples were packaged in coolers and shipped to the laboratories weekly.

4.2.6.3 Groundwater Sampling Procedures

Four groundwater samples were collected at pre-approved locations; two from existing wells identified from the 2013 well survey Letter Report (plus one duplicate and one QA), and two from wells installed in support of the RI. The wells were purged using low-flow methods to stabilization of parameters. Purge water was collected, stored in 55-gallon drums and sampled for determination of disposal methods. The groundwater sampling followed procedures established in the 2013 work plan revision to include groundwater sampling. The YSI Horiba water quality meter was used in the field for analysis of pH, conductivity, turbidity, dissolved oxygen, and temperature. Samples were analyzed by APPL, Inc for MC metals, explosives, ammonium picrate, and perchlorate. Perchlorate samples were filtered with 0.2 micron filter, pre-filtering was not necessary. The samples were collected in pre-cleaned containers provided by the laboratory. Samples were kept on ice until shipment to the appropriate laboratory.

4.2.6.4 Composite Samples at Blow-in-Place Locations

Field teams collected pre- and post-detonation composite soil samples using the Cold Regions Research & Engineering Laboratory (CRREL) 7-sample wheel approach described in Engineer Research and Development Center (ERDC) Special Report 96-15, titled *Assessment of Sampling Error Associated with Collection and Analysis of Soil Samples at Explosives-Contaminated Sites.* For each sample, the sampler donned a new pair of disposable latex or nitrile gloves and used only clean, decontaminated sampling equipment for sample collection. Samples were stored in a drop freezer set at the temperatures specified in the SAP. Samples were packaged in coolers and shipped to the laboratories weekly.

4.2.7 Sampling Analysis

4.2.7.1 Soil, Surface Water and Sediment Samples

Soil, surface water, and sediment samples were shipped to RTI Laboratories (RTI), in Lithonia, Michigan. Samples submitted to RTI were analyzed for explosives and metals [U.S. Environmental Protection Agency (USEPA) Method 8330, USEPA Method 6010, and USEPA Methods 7470 and 7471, respectively], in accordance with the FSP and QAPP. All analytical data were verified prior to being released by RTI. Verification included both editorial and

technical reviews. Laboratory extraction, analysis methods, and target analytes were conducted in accordance with the WP.

Soil, surface water, and sediment QA samples were shipped to TestAmerica, Inc. (TestAmerica), in Denver, Colorado. QA samples were analyzed for explosives and metals (USEPA Method 8330, USEPA Method 6010, and USEPA Methods 7470 and 7471, respectively), in accordance with the FSP and QAPP. All analytical data were verified prior to being released by TestAmerica. Verification included both editorial and technical reviews. Laboratory extraction, analysis methods, and target analytes were conducted in accordance with the WP.

Once finalized by the laboratories, Laboratory Data Consultants, Inc. (LDC) validated all the analytical data generated during the soil, surface water, and sediment sampling effort in accordance with the requirements identified in the work plan and QAPP. The validation included requirements in Department of Defense (DoD) Quality System Manual (QSM) version 3, USEPA SW 846 methods. Data validation reports (DVR) were generated by LDC for all data packages and are provided in Appendix B. The DVRs noted that all data are usable.

4.2.7.2 Groundwater Sample Analysis

Groundwater samples were shipped to APPL, Inc. in Clovis, California. Samples submitted to APPL were analyzed for eight MC metals (aluminum, antimony, barium, chromium, copper, lead, mercury, and zinc) by EPA methods 6020A/7470A; explosives (8330B), ammonium picrate (8321A), and perchlorate (6850), chloride (EPA 300.0), and nitrate/nitrite as N (EPA 353.2) in accordance with the QAPP. QA and QC samples were collected according to the approved work plan. All analytical data were verified prior to being released by APPL. Verification included both editorial and technical reviews. Laboratory extraction, analysis methods, and target analytes were conducted in accordance with the WP.

Sample PR-CUL-GW-MRS-06-10 was collected as a duplicate of PR-CUL-GW-MRS-06-09. The QA sample (PR-CUL-GW-MRS-06-6 QA) was analyzed by Katahdin Analytical Services, Scarborough, Maine, with perchlorate analysis subcontracted to Microbac Laboratory. Due to the limitation of finding a QA lab for the ammonium picrate analysis, APPL served as both primary lab and QA lab for the ammonium picrate analysis under the following conditions: (1) APPL used a different standard as the primary and second source as the parent sample; (2) APPL established a different initial calibration curve (ICAL) with different standard from the parent sample; (3) a different internally qualified technician extracted the QA sample than the primary sample; and (4) APPL will issue a separate lab data package for the QA sample with its own associated lab QC runs. This was approved via email by the Technical Manager of USACE on 22 Nov. 2013. Groundwater samples were validated by Parsons.

4.2.8 Establishment of Background and Preliminary Screening Values

4.2.8.1 Background Concentrations for Metals in Soil and Sediment

Background soil samples were collected from nine soil type areas, (some were located outside the MRSs covered by the RI) that a review of historical documentation indicated were not affected by DoD activities. The background soil samples were analyzed for metals using USEPA Methods SW6020A/6020B and explosives (8330B). Complete analytical results for these analyses are included in Appendix B. For each soil type, background threshold values

(BTVs) for metals were determined to be twice the average concentration detected in the background soil samples; these BTVs are presented in Table 4-4. Background samples for sediment were not collected because there was not an appropriate ambient sampling location for sediment. Since background metals concentrations vary by soil type across Culebra Island, background concentrations of metals in sediment are represented by the BTVs for the soil type most similar to sediment samples collected at the site. Any detected MC in an environmental medium without facility-specific background data, such as explosives, were considered COPC, and have been considered COPC and evaluated in the screening level risk assessment (SLRA).

Table 4-4: Soil Background Threshold Values by Soil Type

Analyte	Units	Background Threshold Value (1)(2)(3)					
		Soil Type Ts(3)	Soil Type AmC2	Soil Type Tf	Soil Type Rs	Soil Type DeE2	Soil Type DrF
Metals							
Aluminum	mg/kg	27,000	44,000	56,000	57,000	55,000	56,000
Antimony	mg/kg	0.32	0.75	0.23	1.3	1.2	0.30
Barium	mg/kg	38	360	670	960	710	430
Chromium	mg/kg	26	24	31	34	23	30
Copper	mg/kg	189	350	250	310	360	140
Lead	mg/kg	18	14	20	220	98	17
Mercury	mg/kg	0.052	0.048	0.085	0.60	0.051	0.032
Zinc	mg/kg	164	200	130	500	350	220

Notes:

(1) - Background concentrations determined to be twice the average concentration detected in all background soil samples of the soil type.

(2) - Five Samples were collected for each soil type

(3) - The values for soil type Ts are presented for information al purposes, but may not be valid due to munition findings nearby and detections of explosives in two of the samples. However, there were no soil samples collected in this soil type in the RI.

4.2.8.2 Background Concentrations for Metals in Surface Water

Three surface water samples were collected from a Cornello Lagoon in MRS 09 in an area identified from historic data as likely not impacted by DoD activities and not down gradient of DoD impacted areas. The unfiltered background surface water samples were analyzed for metals and explosives using USEPA Method SW6020A/3020A. Complete analytical results for these analyses are included in Appendix B. Since explosives were not detected, the historical data of no DoD use is supported. BTVs were determined to be twice the average concentration detected in the background surface water samples. The surface water BTVs are presented in Table 4-5. Any detected MC in an environmental medium without facility-specific background data, such as explosives, were considered COPCs, and have been evaluated in the SLERA step of the baseline risk assessment.

4.2.8.3 Background Concentrations for Metals in Ground Water

No background sampling was conducted for groundwater. Groundwater results were compared to USEPA Regional Screening Levels (RSLs) for Tapwater, (Target Risk = 10-6; Hazard Quotient = 0.1), November 2013, or to a MCL if no RSL is available.

Table 4-5: Surface Water Background Threshold Values

Analyte	Units	Background Threshold Value (1)
Metals		
Aluminum	µg/L	1,700
Antimony	µg/L	3.5
Barium	µg/L	360
Chromium	µg/L	3.1
Copper	µg/L	30
Lead	µg/L	0.41
Mercury	µg/L	ND
Zinc	µg/L	23

Notes: (1) -Background concentrations calculated as twice the average concentration detected in all background surface water samples.

ND – Not Detected.

4.2.8.4 Selection of Preliminary Screening Values

For soil, sediment, and surface water, Preliminary Screening Values (PSVs) for MC metals are selected using a two-step process: 1) first, the most conservative screening value is determined from the applicable human health and ecological screening values (Table 4-6); and 2) second, this screening value is compared to the applicable site-specific background concentration by soil type, and the greater of the two values is selected as the PSV. Explosives do not have background concentrations; therefore, screening values for explosives were determined by choosing the more conservative value between the applicable human health and ecological screening values. No back ground values are available for groundwater samples and ecological receptors are not evaluated for groundwater; therefore, the Human Health screening value is the PSV for groundwater.

PSVs for explosives are presented for soil, sediment, surface water and groundwater in Table 4-7 and Table 4-8. The contaminant-specific screening values for metals in each soil type are presented in Tables 4-9 through 4-16, the screening values for metals in groundwater are presented in Table 4-17. Chromium is evaluated by the following method: If screening criteria are available for chromium (III) and chromium (VI), the biased sample results for chromium (total) will be compared to the BTV prior to comparison to a screening value. If chromium (total) is detected above the BTV, then the chromium (exposure point concentration) EPC will be estimated assuming that total chromium is composed of chromium (VI) and chromium (III) in a one to six ratio. The estimated chromium (VI) concentration is calculated by dividing the measured chromium (total) concentration by seven.

Table 4-6: Background Concentrations and Risk Assessment Screening Values used for the Determination of Preliminary Screening Values

Media	Background Threshold Values(1)	Human Health Screening Values	Ecological Screening Values
Soil	Twice the mean detected ambient concentrations for metals	Soil: /Sediment Soil: U.S. Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs), Residential Soil Criteria (TR= 10^{-6} and HQ = 0.1	USEPA EcoSSLs; If USEPA EcoSSLs are unavailable, use Region 4 Ecological Screening Values (ESVs), USEPA Region 5 Ecological Screening Levels (ESLs), or Los Alamos National Laboratory (LANL) EcoRisk Database values, as appropriate.
Sediment	Twice the mean detected ambient concentrations for metals for parent soil type		USEPA Region 4 Ecological Screening Values for Sediment, November 30, 2001
Surface water	Twice the mean detected ambient concentrations for metals	PREQB WQS supplemented with USEPA RSLs Residential Tapwater Criteria; If either are unavailable, use USEPA MCLs, National Primary Drinking Water Standards	USEPA Region 4 ESVs for Freshwater Surface Water; If USEPA Region 4 ESVs are not available, use USEPA Region 5 ESVs, USEPA Region 3 Ecological Screening Benchmarks for Freshwater, or Los Alamos National Laboratory (LANL) Ecorisk Database values as appropriate.
Groundwater	N/A	PREQB Water Quality Standards for Class SG groundwater) supplemented with 1) USEPA Maximum Contaminant Levels (MCLs); 2) USEPA RSLs for Tapwater (TR= 10^{-6} and HQ = 0.1).	Not evaluated for groundwater.

(1) – Soil background concentrations of metals were established by collecting soil samples from similar soil types from locations across Culebra Island avoiding locations known to have been used for munitions activities (ambient), and surface water samples in locations upgradient from areas used for munitions activities. Background values for metals were calculated as two times the average detected ambient concentration. There are no applicable background values for explosives, perchlorate, or ammonium picrate.

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Table 4-7: Preliminary Screening Values for Explosives (Soil, Sediment, and Surface Water)

Analyte	SOIL			SEDIMENT			SURFACE WATER		
Explosives - SW8330	Human Health Screening Values [1] (mg/kg) USEPA RSLs	Ecological Screening Values [2] (mg/kg) USEPA Eco SSLs (*unless noted*)	Preliminary Screening Value [3] (mg/kg)	Human Health Screening Values [1] (mg/kg) USEPA RSLs	Ecological Screening Values (mg/kg) USEPA Region 4 ESVs [4] (*unless noted*)	Preliminary Screening Value [3] (mg/kg)	Human Health Screening Values (µg/L) USEPA Tapwater RSLs [5]	Ecological Screening Values (µg/L) USEPA Region 4 ESVs [6] (*unless noted*)	Preliminary Screening Value [3] (µg/L)
1,3,5-Trinitrobenzene	*220*	**0.38** [7]	0.38	***220***	1,300 [8]	220	***8.7***	60,000 [9]	8.7
1,3-Dinitrobenzene	***0.61***	0.66 [7]	0.61	*0.61*	**0.009** [11]	0.009	***0.15***	22 [12]	0.15
2,4,6-Trinitrobenzene	19	**6.4** [10]	6.4	19	**0.092** [14]	0.092	**2.2**	100 [15]	2.2
2,4-Dinitrotoluene	1.6	**1.3** [7]	1.3	1.6	**0.014** [11]	0.014	**0.20**	310	0.20
2,6-Dinitrotoluene	*6.1*	**0.033** [7]	0.033	*6.1*	**0.04** [11]	0.04	***1.5***	60 [9]	1.5
2-Amino-4,6-dinitrotoluene	*15*	**10** [10]	10	***15***	34 [8]	15	***3.0***	1,500 [15]	3.0
2-Nitrotoluene	**2.9**	9.9 [10]	2.9	**2.9**	28 [8]	2.9	**0.27**	39,000 [9]	0.27
3-Nitrotoluene	***0.61***	12 [10]	0.61	***0.61***	24 [8]	0.61	***0.13***	750 [15]	0.13
4-Amino-2,6-dinitrotoluene	*15*	**3.6** [10]	3.6	*15*	**9.5** [8]	9.5	***3.0***	43,000 [9]	3.0
4-Nitrotoluene	30	**22** [10]	22	30	**4.1** [14]	4.1	**3.7**	1,900 [15]	3.7
Hexahydro-1,3,5-trinitro-1,3,5-triazine	**5.6**	7.5 [10]	5.6	5.6	**0.013** [14]	0.013	**0.61**	360 [15]	0.61
Nitrobenzene	4.8	**1.3** [7, 13]	1.3	4.8	**0.51**	0.51	**0.12**	270	0.12
Nitroglycerin	***0.61***	71 [10]	0.61	***0.61***	1,700 [8]	0.61	***0.15***	140 [15]	0.15
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	*380*	**27** [10]	27	***380***	27,000 [8]	380	***78***	150 [15]	78
PETN	120	**100** [10]	100	**120**	1,400 [8]	120	**16**	85,000 [15]	16
Methyl-2,4,6-trinitrophenylnitramine(tetryl)	*24*	**0.99** [10]	0.99	***24***	100 [8]	24	***6.3***	5,800 [9]	6.3

Notes:

(1) USEPA Regional Screening Level (RSL) Summary Table, residential soil, May 2012 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf). Noncarcinogenic RSLs were divided by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. Adjusted values are shown in *italics*.

(2) USEPA Ecological Soil Screening Levels (Eco SSL), various updates (http://www.epa.gov/ecotox/ecossl/).

(3) The PSVs for this RI were selected using a two-step process: a) first, the most conservative screening value was determined from the applicable human health screening values (USEPA RSLs) and ESVs (USEPA Eco SSLs, or Region 4, Region 5, or LANL EcoRisk Database value in the absence of a USEPA Eco SSL); b) second, this screening value was compared to the applicable soil-specific background value, and the greater of the two was selected as the PSV. The selected PSV is shown in **bold**.

(4) USEPA Region 4 Ecological Screening Values for Sediment, November 30, 2001 (http://www.epa.gov/region4/superfund/programs/riskassess/ecolbul.html#tbl3).

(5) USEPA Regional Screening Level (RSL) Summary Table, Tap water, May 2012 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf). Noncarcinogenic RSLs were divided by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. Adjusted values are shown in *italics*.

(6) USEPA Region 4 Ecological Screening Values for Freshwater Surface Water, November 30, 2001 (http://www.epa.gov/region4/superfund/programs/riskassess/ecolbul.html#tbl1).

(7) No USEPA Eco SSL available. Used USEPA Region 5 ecological screening values, August 22, 2003 (http://www.epa.gov/Region5/waste/cars/pdfs/ecological-screening-levels-200308.pdf).

(8) No USEPA Region 4 ESV for sediment available. Used Los Alamos National Laboratory, Eco Risk Database (Release 3.0), October 2011 (http://www.lanl.gov/environment/cleanup/ecorisk.shtml).

(9) No USEPA Region 4 ESV for surface water available. Used Los Alamos National Laboratory, Eco Risk Database (Release 3.0), October 2011 (http://www.lanl.gov/environment/cleanup/ecorisk.shtml).

(10) No USEPA Eco SSL available. Used Los Alamos National Laboratory, Eco Risk Database (Release 3.0), October 2011 (http://www.lanl.gov/environment/cleanup/ecorisk.shtml).

(11) No USEPA Region 4 ESV for sediment available. Used USEPA Region 5 ecological screening values, August 22, 2003 (http://www.epa.gov/Region5/waste/cars/pdfs/ecological-screening-levels-200308.pdf).

(12) No USEPA Region 4 ESV for surface water available. Used USEPA Region 5 ecological screening values, August 22, 2003 (http://www.epa.gov/Region5/waste/cars/pdfs/ecological-screening-levels-200308.pdf).

(13) No USEPA Eco SSL available. Used 1.3 mg/kg for nitrobenzene (USEPA Region 5 Ecological Screening Level) rather than the USEPA Region 4 Ecological Screening Value for soil [40mg/kg] at request of EQB.

(14) No USEPA Region 4 ESV for sediment available. Used USEPA Region 3 Ecological Screening Benchmarks for Freshwater Sediment, March 19, 2010 (http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/screenbench.htm).

(15) No USEPA Region 4 ESV for surface water available. Used USEPA Region 3 Ecological Screening Benchmarks for Freshwater, March 19, 2010 (http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fw/screenbench.htm).

Table 4-8: Preliminary Screening Values for Explosives, and Ammonium Picrate (Groundwater)

Explosives - SW8330B	Human Health Screening Values (µg/L) USEPA Tapwater RSLs
1,3,5-Trinitrobenzene	*46*
1,3-Dinitrobenzene	*0.15*
2,4,6-Trinitrotoluene	0.76
2,4-Dinitrotoluene	0.20
2,6-Dinitrotoluene	*0.042*
2-Amino-4,6-dinitrotoluene	*3.0*
2-Nitrotoluene	0.27
3-Nitrotoluene	*0.13*
4-Amino-2,6-dinitrotoluene	*3.0*
4-Nitrotoluene	3.7
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	0.61
Nitrobenzene	0.12
Nitroglycerin	*0.15*
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	*78*
PETN	3.0
Methyl-2,4,6-trinitrophenylnitramine(tetryl)	*6.1*
Ammonium Picrate (8321A)	*N/A*

Notes:

A – USEPA Regional Screening Levels (RSLs) for Tapwater (Target Risk = 10-6; Hazard Quotient = 0.1), May 2013. http://www.epa.gov/reg3hwmd/risk/human//rb-concentration_table/Generic_Tables/docs/master_sl_table_01run_MAY2013.pdf

Table 4-9: Preliminary Metals Screening Values for Soil for AmC2 Soil Type

Analyte	Human Health Screening Values (1) (mg/kg)	Ecological Screening Values (2) (mg/kg)	Background Threshold Value (3) (mg/kg)	Preliminary Screening Value (4) (mg/kg)
Metals - SW6020A/SW3050B	**USEPA RSLs**	**USEPA Eco SSLs (unless noted)**		
Aluminum	7,700	50 (5,6)	44,000	44,000
Barium	1,500	330	1,200	1,200
Chromium	12,000 (7)	26	24	26
Copper	310	28	350	350
Lead	400	11	14	14
Zinc	2,300	46	200	200
Antimony	3.1	0.27	0.75	0.75
Mercury	1.0 (8)	0.1 (5)	0.048	0.13

Notes:

(1) USEPA Regional Screening Level (RSL) Summary Table, residential soil, May 2012 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf). When appropriate, noncarcinogenic RSLs were divided by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. Adjusted values are shown in *italics*.

(2) USEPA Ecological Soil Screening Levels, various updates (http://www.epa.gov/ecotox/ecossl/).

(3) The background values are two times the mean concentrations detected in the background samples collected from soil type AmC2 (see Table 4-4).

(4) The PSVs for this RI were selected using a two-step process: a) first, the most conservative screening value was determined from the applicable human health screening values (USEPA RSLs) and ESVs (USEPA Eco SSLs, or Region 4, Region 5, or LANL Eco Risk Database value in the absence of a USEPA Eco SSL); b) second, this screening value was compared to the applicable soil-specific background value, and the greater of the two was selected as the PSV. The selected PSVs are shown in **bold** where applicable.

(5) No USEPA Eco SSL available. Used USEPA Region 4 Ecological Screening Values for Soil (http://www.epa.gov/region4/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf).

(6) ESV for aluminum is only applicable when the pH is extremely low (less than 5.5).

(7) Value is for Chromium III.

(8) Value is for Elemental Mercury, consistent with Worksheet #15 of the RI/FS Quality Assurance Project Plan.

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Table 4-10: Preliminary Metals Screening Values for Soil for Tf Soil Type

	Human Health Screening Values (1)	Ecological Screening Values(2)	Background Threshold Value (3)	Preliminary Screening Value (4)
Analyte	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Metals - SW6020A/SW3050B	**USEPA RSLs**	**USEPA Eco SSLs (unless noted)**		
Aluminum	7,700	50 (5,6)	**56,000**	56,000
Barium	1,500	330	**670**	670
Chromium	12,000 (7)	26	**31**	31
Copper	310	28	**250**	250
Lead	400	11	**20**	20
Zinc	2,300	46	**130**	130
Antimony	3.1	**0.27**	0.23	0.27
Mercury	1.0 (8)	**0.1** (5)	0.085	0.13

Notes:

(1) USEPA Regional Screening Level (RSL) Summary Table, residential soil, May 2012 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf). As appropriate, noncarcinogenic RSLs were divided by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. Adjusted values are shown in *italics*.

(2) USEPA Ecological Soil Screening Levels, various updates (http://www.epa.gov/ecotox/ecossl/).

(3) The background values are two times the mean concentrations detected in the background samples collected from soil type Tf (see Table 4-4).

(4) The PSVs for this RI were selected using a two-step process: a) first, the most conservative screening value was determined from the applicable human health screening values (USEPA RSLs) and ESVs (USEPA Eco SSLs, or Region 4, Region 5, or LANL Eco Risk Database value in the absence of a USEPA Eco SSL); b) second, this screening value was compared to the applicable soil-specific background value, and the greater of the two was selected as the PSV. The selected PSV are shown in bold where applicable.

(5) No USEPA Eco SSL available. Used USEPA Region 4 Ecological Screening Values for Soil (http://www.epa.gov/region4/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf).

(6) ESV for aluminum is only applicable when the pH is extremely low (less than 5.5).

(7) Value is for Chromium III.

(8) Value is for Elemental Mercury, consistent with Worksheet #15 of the RI/FS Quality Assurance Project Plan.

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Table 4-11: Preliminary Metals Screening Values for Soil for Rs Soil Type

	Human Health Screening Values [1]	Ecological Screening Values[2]	Background Threshold Value [3]	Preliminary Screening Value[4]
Analyte	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Metals - SW6020A/SW3050B	**USEPA RSLs**	**USEPA Eco SSLs (*unless noted*)**		
Aluminum	7,700	50 [5,6]	**57,000**	57,000
Barium	1,500	330	**960**	960
Chromium	12,000 [7]	26	**34**	34
Copper	310	28	**310**	310
Lead	400	11	**220**	220
Zinc	2,300	46	**500**	500
Antimony	3.1	0.27	**1.3**	1.3
Mercury	1.0 [8]	0.1[5]	**0.60**	0.60

Notes:

(1) USEPA Regional Screening Level (RSL) Summary Table, residential soil, May 2012 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf). As appropriate, noncarcinogenic RSLs were divided by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. Adjusted values are shown in *italics*.

(2) USEPA Ecological Soil Screening Levels, various updates (http://www.epa.gov/ecotox/ecossl/).

(3) The background values are two times the mean concentrations detected in the background samples collected from soil type Rs (see Table 4-4).

(4) The PSVs for this RI were selected using a two-step process: a) first, the most conservative screening value was determined from the applicable human health screening values (USEPA RSLs) and ESVs (USEPA Eco SSLs, or Region 4, Region 5, or LANL Eco Risk Database value in the absence of a USEPA Eco SSL); b) second, this screening value was compared to the applicable soil-specific background value, and the greater of the two was selected as the PSV. The selected PSVs are shown in bold where applicable.

(5) No USEPA EcoSSL available. Used USEPA Region 4 Ecological Screening Values for Soil (http://www.epa.gov/region4/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf).

(6) ESV for aluminum is only applicable when the pH is extremely low (less than 5.5).

(7) Value is for Chromium III.

(8) Value is for Elemental Mercury, consistent with Worksheet #15 of the RI/FS Quality Assurance Project Plan.

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Table 4-12: Preliminary Metals Screening Values for Soil for DeE2 Soil Type

	Human Health Screening Values [1]	Ecological Screening Values[2]	Background Threshold Value [3]	Preliminary Screening Value[4]
Analyte	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Metals - SW6020A/SW3050B	**USEPA RSLs**	**USEPA Eco SSLs (*unless noted*)**		
Aluminum	7,700	50 [5,6]	**55,000**	55,000
Barium	1,500	330	**710**	710
Chromium	12,000 [7]	**26**	23	26
Copper	310	28	**360**	360
Lead	400	11	**98**	98
Zinc	2,300	46	**350**	350
Antimony	3.1	0.27	**1.2**	1.2
Mercury	1.0 [8]	**0.1** [5]	0.051	0.13

Notes:

(1) USEPA Regional Screening Level (RSL) Summary Table, residential soil, May 2012 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf). As appropriate, noncarcinogenic RSLs were divided by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. Adjusted values are shown in *italics*.

(2) USEPA Ecological Soil Screening Levels, various updates (http://www.epa.gov/ecotox/ecossl/).

(3) The background values are two times the mean concentrations detected in the background samples collected from soil type DeE2 (see Table 4-4).

(4) The PSVs for this RI were selected using a two-step process: a) first, the most conservative screening value was determined from the applicable human health screening values (USEPA RSLs) and ESVs (USEPA Eco SSLs, or Region 4, Region 5, or LANL Eco Risk Database value in the absence of a USEPA Eco SSL); b) second, this screening value was compared to the applicable soil-specific background value, and the greater of the two was selected as the PSV. The selected PSV are shown in bold where applicable.

(5) No USEPA EcoSSL available. Used USEPA Region 4 Ecological Screening Values for Soil (http://www.epa.gov/region4/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf).

(6) ESV for aluminum is only applicable when the pH is extremely low (less than 5.5).

(7) Value is for Chromium III.

(8) Value is for Elemental Mercury, consistent with Worksheet #15 of the RI/FS Quality Assurance Project Plan..

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Table 4-13: Preliminary Metals Screening Values for Soil for DrF Soil Type

	Human Health Screening Values [1]	Ecological Screening Values[2]	Background Threshold Value [3]	Preliminary Screening Value[4]
Analyte	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Metals - SW6020A/SW3050B	**USEPA RSLs**	**USEPA Eco SSLs (*unless noted*)**		
Aluminum	7,700	50 [5,6]	**56,000**	56,000
Barium	1,500	330	**430**	430
Chromium	12,000 [7]	26	**30**	30
Copper	310	28	**140**	140
Lead	400	11	**17**	17
Zinc	2,300	46	**220**	220
Antimony	3.1	0.27	**0.30**	0.30
Mercury	1.0 [8]	**0.1** [5]	0.032	0.13

Notes:

(1) USEPA Regional Screening Level (RSL) Summary Table, residential soil, May 2012 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf). As appropriate, noncarcinogenic RSLs were divided by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. Adjusted values are shown in *italics*.

(2) USEPA Ecological Soil Screening Levels, various updates (http://www.epa.gov/ecotox/ecossl/).

(3) The background values are two times the mean concentrations detected in the background samples collected from soil type DrF (see Table 4-4).

(4) The PSVs for this RI were selected using a two-step process: a) first, the most conservative screening value was determined from the applicable human health screening values (USEPA RSLs) and ESVs (USEPA Eco SSLs, or Region 4, Region 5, or LANL Eco Risk Database value in the absence of a USEPA Eco SSL); b) second, this screening value was compared to the applicable soil-specific background value, and the greater of the two was selected as the PSV. The selected PSVs are shown in **bold** where applicable.

(5) No USEPA EcoSSL available. Used USEPA Region 4 Ecological Screening Values for Soil (http://www.epa.gov/region4/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf).

(6) ESV for aluminum is only applicable when the pH is extremely low (less than 5.5).

(7) Value is for Chromium III.

(8) Value is for Elemental Mercury, consistent with Worksheet #15 of the RI/FS Quality Assurance Project Plan..

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Table 4-14: Preliminary Metals Screening Values for Soil for Ts Soil Type

	Human Health Screening Values [1]	Ecological Screening Values[2]	Background Threshold Value [3]	Preliminary Screening Value [4]
Analyte	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Metals - SW6020A/SW3050B	**USEPA RSLs**	**USEPA Eco SSLs (*unless noted*)**		
Aluminum	7,700	50 [5,6]	**27,000**	27,000
Barium	1,500	**330**	38	330
Chromium	12,000 [7]	**26**	**26**	26
Copper	310	28	**189**	189
Lead	400	11	**18**	18
Zinc	2,300	46	**164**	164
Antimony	3.1	0.27	**0.32**	0.32
Mercury	1.0 [8]	**0.1** [5]	0.052	0.13

Notes:

Note these values are presented for informational purposes only. No samples were collected from this soil type.

(1) USEPA Regional Screening Level (RSL) Summary Table, residential soil, May 2012 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf). As appropriate, noncarcinogenic RSLs were divided by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. Adjusted values are shown in *italics*.

(2) USEPA Ecological Soil Screening Levels, various updates (http://www.epa.gov/ecotox/ecossl/).

(3) The background values are two times the mean concentrations detected in the background samples collected from soil type AmC2 (see Table 4-4).

(4) The PSVs for this RI were selected using a two-step process: a) first, the most conservative screening value was determined from the applicable human health screening values (USEPA RSLs) and ESVs (USEPA Eco SSLs, or Region 4, Region 5, or LANL EcoRisk Database value in the absence of a USEPA Eco SSL); b) second, this screening value was compared to the applicable soil-specific background value, and the greater of the two was selected as the PSV. The selected PSVs are shown in **bold** where applicable.

(5) No USEPA EcoSSL available. Used USEPA Region 4 Ecological Screening Values for Soil (http://www.epa.gov/region4/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf).

(6) ESV for aluminum is only applicable when the pH is extremely low (less than 5.5).

(7) Value is for Chromium III.

(8) Value is for Elemental Mercury, consistent with Worksheet #15 of the RI/FS Quality Assurance Project Plan.

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Table 4-15: Preliminary Metals Screening Values for Sediment for Rs Soil Type

	Human Health Screening Values (1)	Ecological Screening Values(2)	Background Threshold Value (3)	Preliminary Screening Value(4)
Analyte	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Metals - SW6020A/SW3050B	**USEPA RSLs**	**USEPA Region 4 ESVs (*unless noted*)**		
Aluminum	7,700	280 (5)	**57,000**	57,000
Barium	1,500	48 (5)	**960**	960
Chromium	12,000 (7)	**52**	34	52
Copper	310	19	**310**	310
Lead	400	30	**220**	220
Zinc	2,300	120	**500**	500
Antimony	**3.1**	12	1.3	3.1
Mercury	1.0 (7)	0.1	**0.60**	0.60

Notes:

(1) USEPA Regional Screening Level (RSL) Summary Table, residential soil, May 2012 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf). As appropriate, noncarcinogenic RSLs were divided by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. Adjusted values are shown in *italics*.

(2) USEPA Region 4 Ecological Screening Values for Sediment, November 30, 2001 (http://www.epa.gov/region4/superfund/programs/riskassess/ecolbul.html#tbl3).

(3) The background values are two times the mean concentrations detected in the background samples collected from soil type Rs (see Table 4-4).

(4) The PSVs for this RI were selected using a two-step process: a) first, the most conservative screening value was determined from the applicable human health screening values (USEPA RSLs) and ESVs (USEPA Region 4 ESVs, or Region 5, or, Region 3, or LANL Eco Risk Database value in the absence of a USEPA Region 4 ESVs); b) second, this screening value was compared to the applicable soil-specific background value, and the greater of the two was selected as the PSV. The selected PSV are shown in bold where applicable.

(5) No USEPA Region 4 ESV for Sediment available. Used Los Alamos National Laboratory, Eco Risk Database (Release 3.0), October 2011 (http://www.lanl.gov/environment/cleanup/ecorisk.shtml).

(6) Value is for Chromium III.

(7) Value is for Elemental Mercury, consistent with Worksheet #15 of the RI/FS Quality Assurance Project Plan.

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Table 4-16: Preliminary Metals Screening Values for Surface Water

	As Noted	Human Health Screening Values (2)	Ecological Screening Values(3)	Background Threshold Value (4)	Preliminary Screening Value (5)
Analyte	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**
Metals - SW6020A/SW3050B	**PREQB WQS(1)**	**USEPA RSLs**	**USEPA Region 4 ESVs (*unless noted*)**		
Aluminum	NA	1,600	87	**1,700**	1,700
Barium	NA	290	220 (6)	**360**	360
Chromium	NA	1,600 (7)	**120**	3.1	120
Copper	3.73 (AL)	61	6.5	**30**	30
Lead	8.52 (AL)	15 (8)	**1.3**	0.41	1.3
Zinc	85.62 (AL)	470	**59**	23	59
Antimony	640 (HH)	0.60	160	**3.5**	3.5
Mercury	.051(HH)	0.063 (9)	**0.012**	ND	0.01

Notes:

(1) PREQB Water Quality Standards for Class SB surface water, March 2010. HH = Human Health; AL=Aquatic Life

(2) USEPA Regional Screening Level (RSL) Summary Table, Tap water, May 2012 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_MAY2012.pdf). As appropriate, noncarcinogenic RSLs were divided by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. Adjusted values are shown in *italics*.

(3) USEPA Region 4 Ecological Screening Values for Freshwater Surface Water, November 30, 2001 (http://www.epa.gov/region4/superfund/programs/riskassess/ecolbul.html#tbl1).

(4) The background values are two times the mean concentrations detected in the background samples collected (Table 4-4).

(5) The PSVs for this RI were selected using a two-step process: a) first, the most conservative screening value was determined from the applicable human health screening values PREQB WQS (USEPA RSLs) and ESVs (USEPA Region 4 ESVs, or Region 5, or, Region 3, or LANL Eco Risk Database value in the absence of a USEPA Eco Region 4 ESVs); b) second, this screening value was compared to the applicable surface water background value, and the greater of the two was selected as the PSV. The selected PSVs are shown in **bold** where applicable.

(6) No USEPA Region 4 ESV available. Used USEPA Region 5 ecological screening values, August 22, 2003 (http://www.epa.gov/Region5/waste/cars/pdfs/ecological-screening-levels-200308.pdf).

(7) Value is for Chromium III.

(8) No USEPA RSL available. Used USEPA MCLs, National Primary Drinking Water Standards, May 4, 2011 (http://www.epa.gov/safewater/contaminants/index.html).

(9) Value is for Elemental Mercury, consistent with Worksheet #15 of the RI/FS Quality Assurance Project Plan. ND = Not detected

Table 4-17: Preliminary Screening Values for Ground Water

	Human Health Screening Values[1]	Human Health Screening Values [2]	PAL
Analyte	**(µg/L)**	**(µg/L)**	
Metals - SW6020A/7470A	**PREQB Water Quality Standards**	**USEPA RSLs (unless otherwise noted)**	
Aluminum	NA	1,600	1,600
Antimony	5.6	0.60	5.6
Barium	NA	290	290
Chromium (Total) [3]	100	N/A	100
Chromium(III)	NA	1,600	1,600
Chromium(IV)	NA	0.031	0.031
Copper	NA	62	62
Lead	15	15 [4]	15
Mercury [5]	.050	0.43	0.05
Zinc	NA	470	470
Perchlorate (6850)	NA	1.1	1.1

N/A – Not Applicable

(1) PREQB Water Quality Standards for Class SB surface water, March 2010.

(2) USEPA Regional Screening Levels (RSLs) for Tapwater (Target Risk = 10-6; Hazard Quotient = 0.1), November 2013. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/docs/master_sl_table_01run_NOV2013.pdf)

(3) Chromium can exist in the environment as chromium (III) and chromium (VI). Analytical results are for chromium (total) and do not distinguish between the different valence states. However, screening criteria are available for chromium (III) and chromium (VI), so the chromium concentrations will be estimated assuming that total chromium is composed of chromium (VI) and chromium (III) in a one to six ratio. The estimated chromium (VI) concentration is calculated by dividing the maximum chromium (total) concentration measured in soil samples by seven. The estimated chromium (III) concentration is the difference of the maximum chromium (total) concentration and the estimated chromium (VI) concentration.

(4) USEPA RSL not established. Used USEPA Maximum Contaminant Level. (http://www.epa.gov/reg3hwmd/risk/human//rb-concentration_table/Generic_Tables/docs/master_sl_table_01run_November2013.pdf)

(5) Used mercuric chloride.

CHAPTER 5. REVISED CONCEPTUAL SITE MODEL AND RI RESULTS

5.1 INTRODUCTION

RI activities were conducted at the Culebra Island MRSs from May 2008 through October 2011. A groundwater well survey was conducted in September 2013, and well installation and groundwater sampling were conducted in December 2013. Investigative work consisted of DGM, intrusive investigation of geophysical anomalies, intrusive investigation using handheld metal detectors (analog mag-and-dig), and sampling and analysis for MC. Findings from a 2009 Post Award site visit are included to augment the RI MEC investigation results in MRS 13. The results of the geophysical/intrusive investigations and MC sampling are detailed below.

5.2 REMEDIAL INVESTIGATION RESULTS

As described in Chapter 4, the RI involved excavation of anomalies selected from DGM data and anomalies identified using handheld metal detectors (analog mag-and-dig) as well as MC sample collection. This section provides a summary of the distribution of MEC, MD, and MC identified from the intrusive investigations. This distribution is evaluated in terms of the historical information related to the munitions demonstrations and munitions-related training that was conducted at the site. This information is, in turn, used to revise the pre-RI CSM that was presented in Chapter 3.

5.3 MUNITIONS AND EXPLOSIVES OF CONCERN (MEC) AND MUNITIONS DEBRIS (MD)

DGM data was collected along upland area transects, and within grids placed in high anomaly density areas. Analog mag-and-dig investigations were used to investigate accessible beach areas and selected trails on MRS 13. The results of the excavation of anomalies, both DGM and analog mag-and-dig, are presented in Table 4-2. During vegetation removal, two MEC items were found on the surface at two locations in MRS 09: two Mk 25 marine flares. These flares were recovered on the surface along transects and not in the intrusive investigation grids, but are included in the results as were shown in Table 4-2. The table presents the number of locations for various data categories. MEC and MD finds represent a very small proportion of the locations investigated. Small arms ammunition is evaluated separately from other MD because they do not represent the same level of hazard. Some locations had multiple MD and non-munitions debris. For MD, the precise number of items at a particular location is not always countable due to the fact that these items are often in pieces. Figures 5-1 through 5-6 show the distribution of the intrusive investigation results for each Culebra Island MRS. The following paragraphs provide a summary of the MD items recovered from each MRS. Appendix G contains tabulated intrusive results for each MRS.

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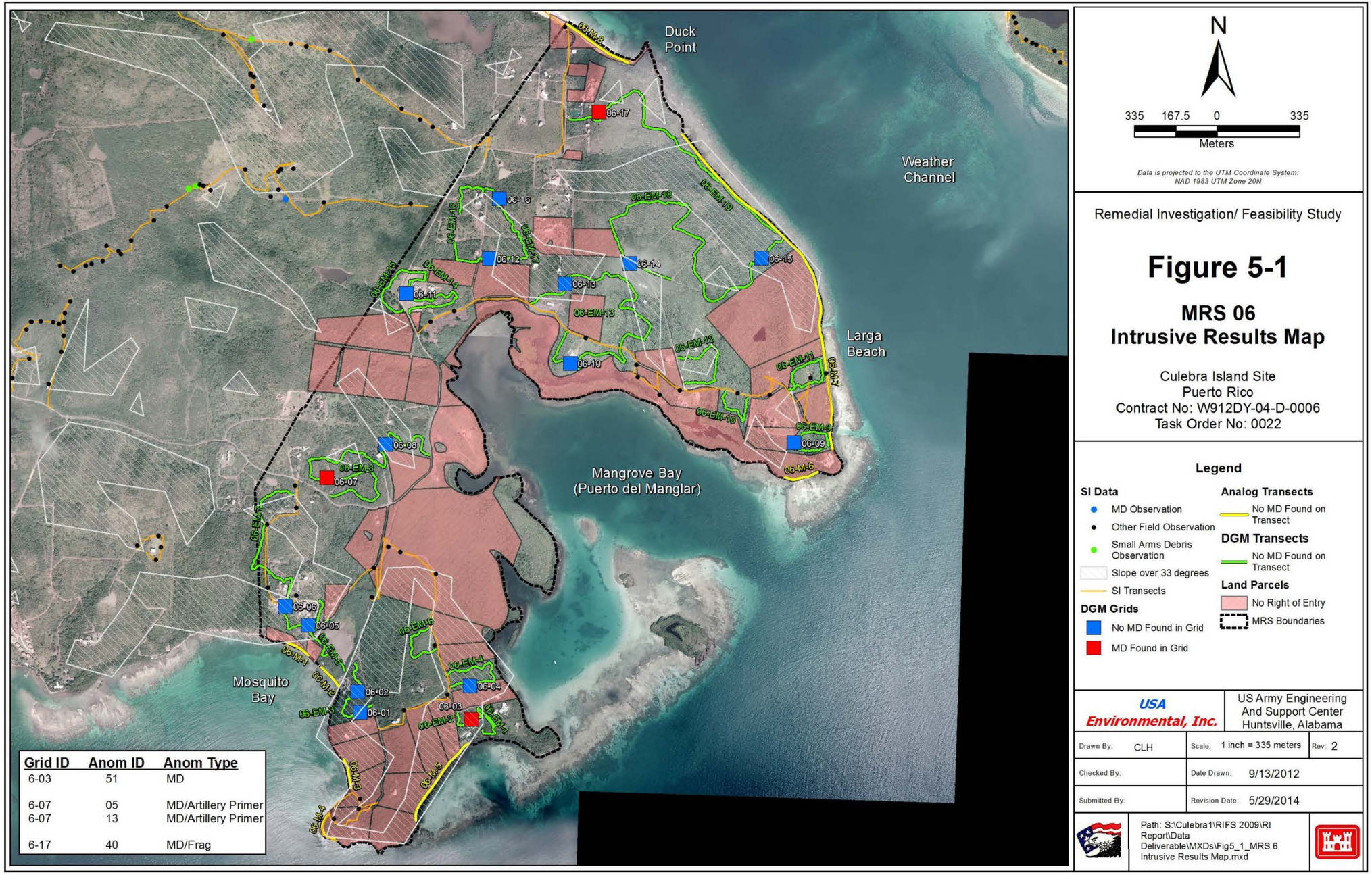

Figure 5-1: MRS 06 Intrusive Results Map

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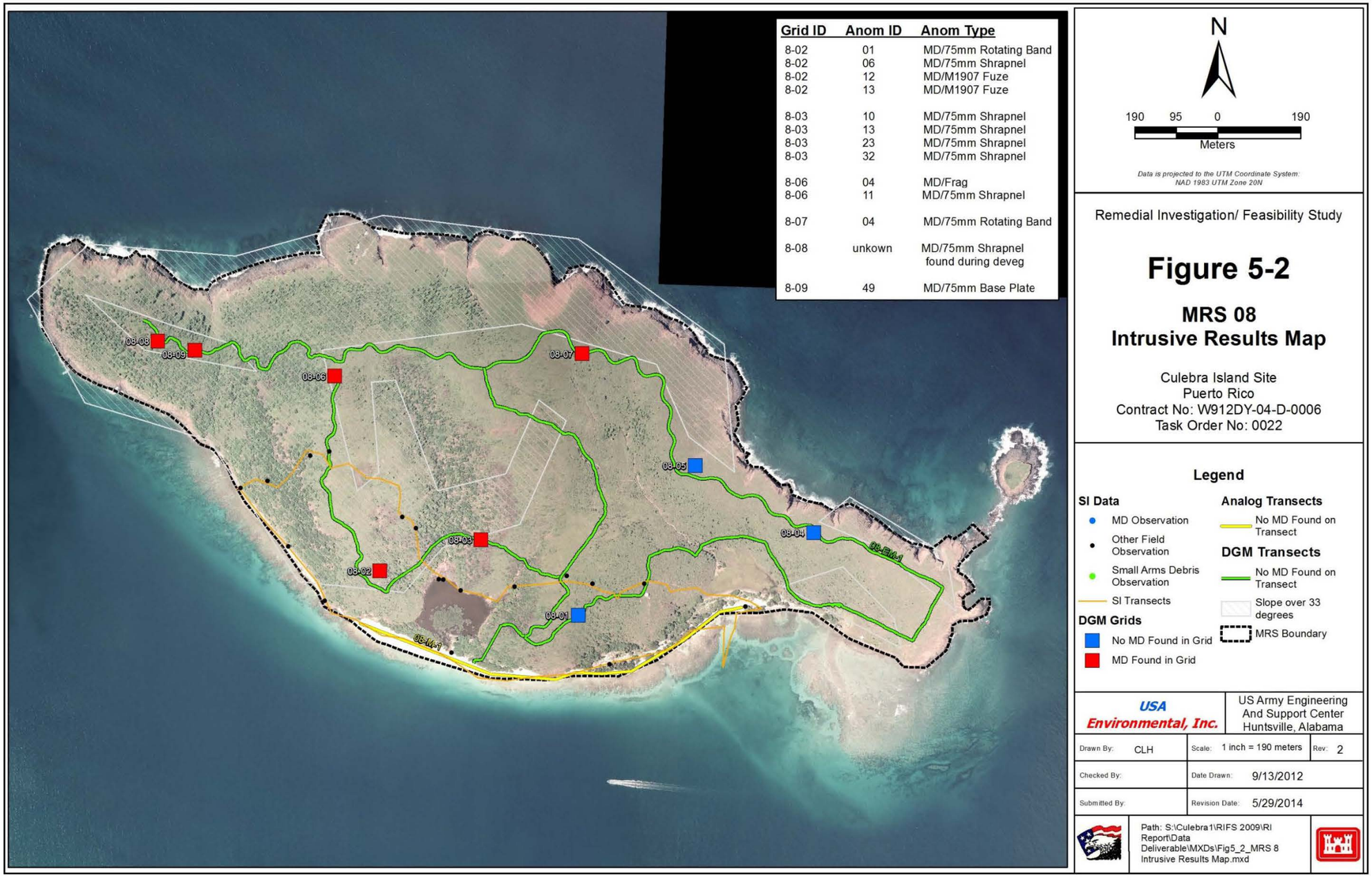

Figure 5-2: MRS 08 Intrusive Results Map

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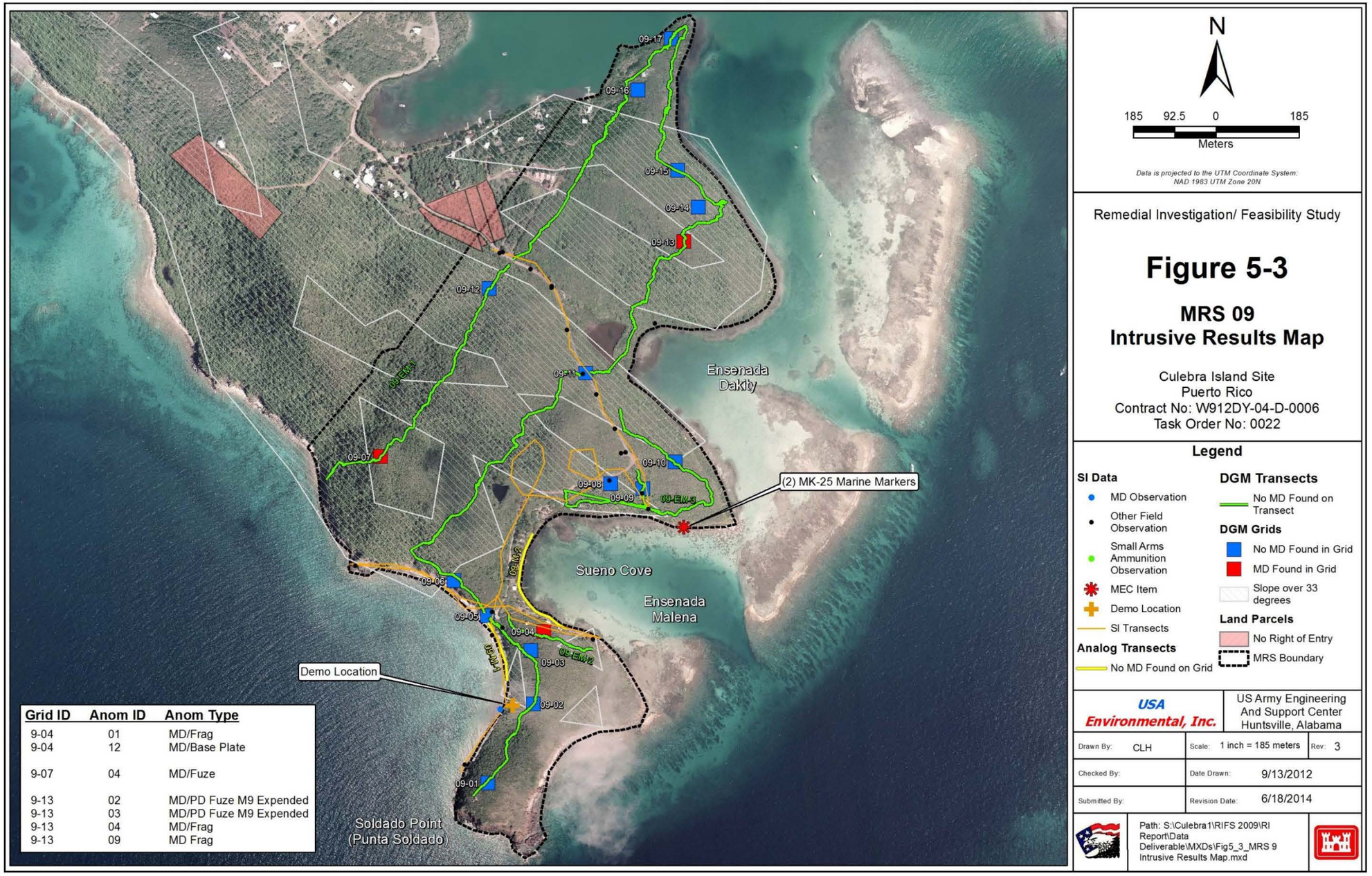

Figure 5-3: MRS 09 Intrusive Results Map

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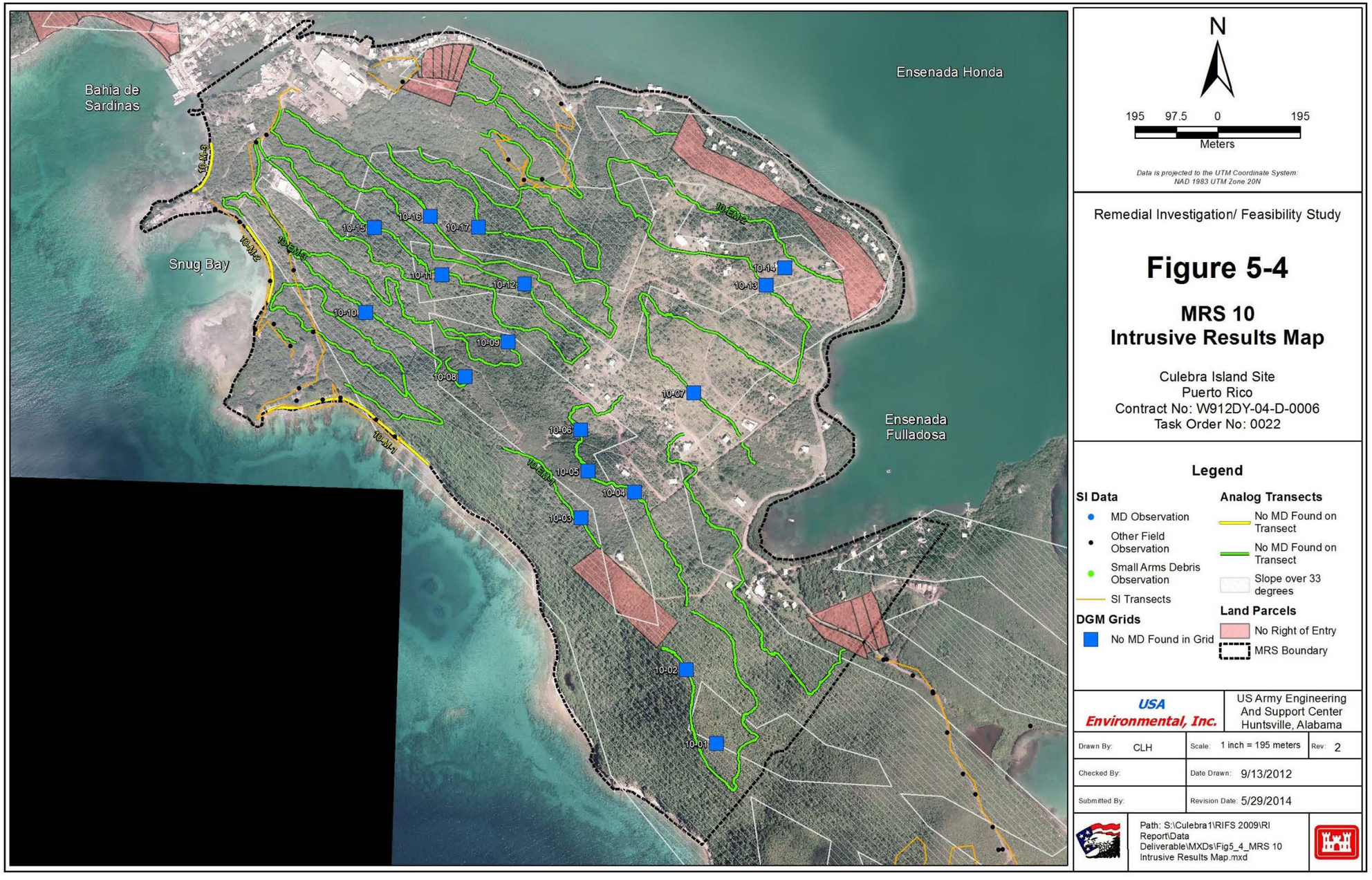

Figure 5-4: MRS 10 Intrusive Results Map

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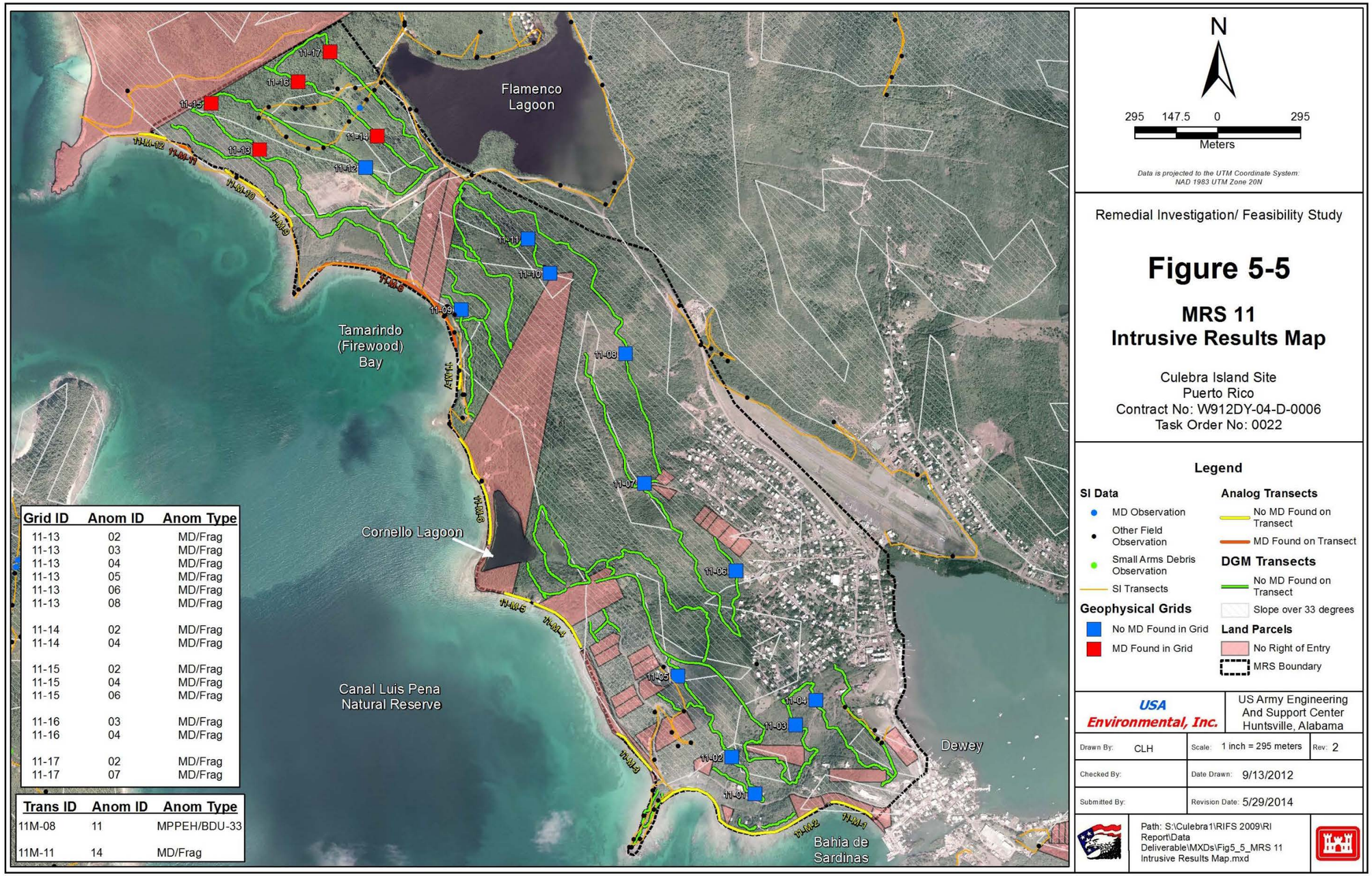

Grid ID	Anom ID	Anom Type
11-13	02	MD/Frag
11-13	03	MD/Frag
11-13	04	MD/Frag
11-13	05	MD/Frag
11-13	06	MD/Frag
11-13	08	MD/Frag
11-14	02	MD/Frag
11-14	04	MD/Frag
11-15	02	MD/Frag
11-15	04	MD/Frag
11-15	06	MD/Frag
11-16	03	MD/Frag
11-16	04	MD/Frag
11-17	02	MD/Frag
11-17	07	MD/Frag

Trans ID	Anom ID	Anom Type
11M-08	11	MPPEH/BDU-33
11M-11	14	MD/Frag

Figure 5-5: MRS 11 Intrusive Results Map

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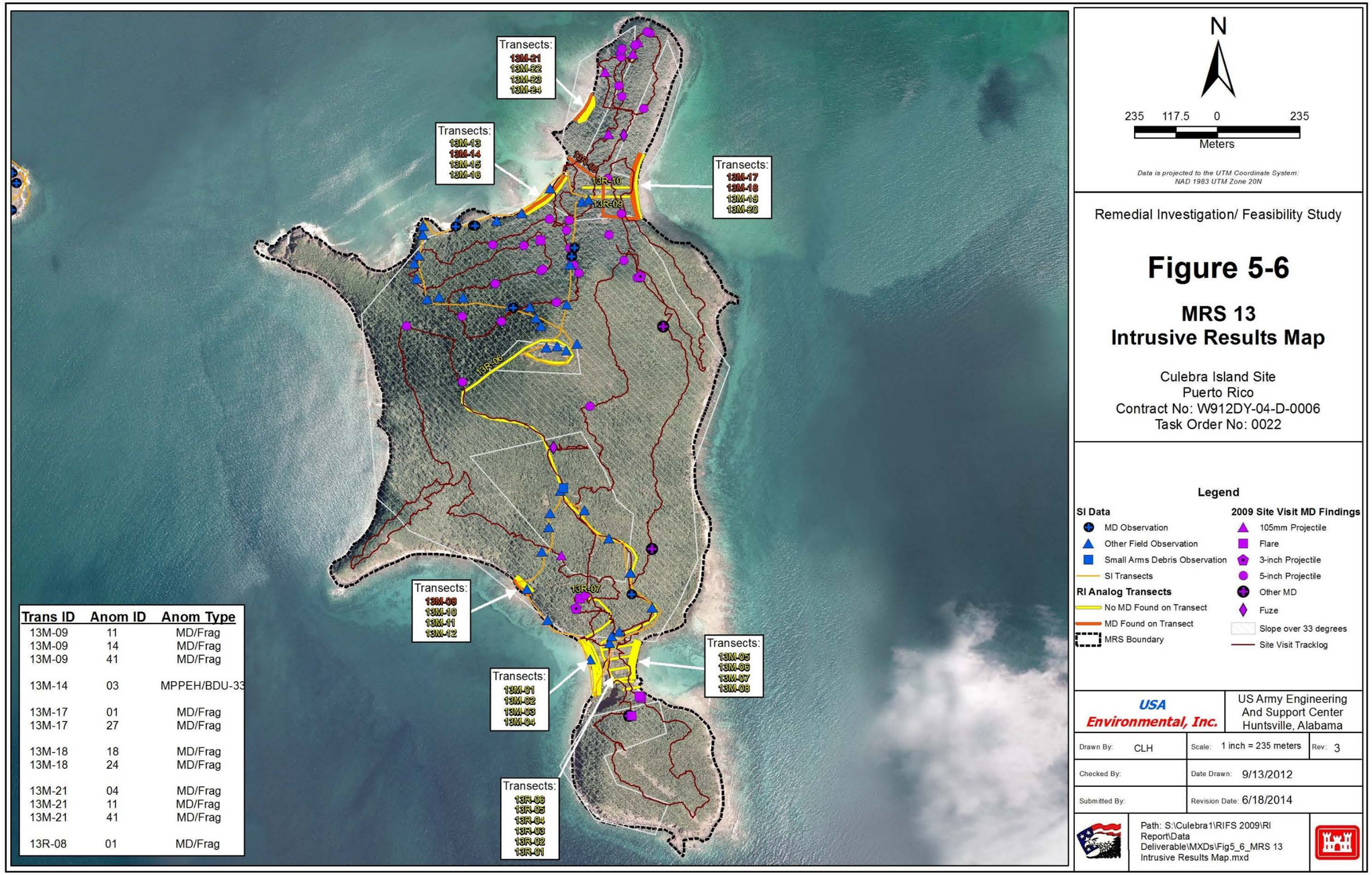

Figure 5-6: MRS 13 Intrusive Results Map

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5.3.1 MRS 06 Artillery Firing Area

MRS 06 was used by the Marines for artillery firing points for exercises conducted between 1922 and the 1940s. Figure 5-1 reflects the intrusive results for MRS 06, as shown on Table 4-2. Only four (4) MD items were recovered in MRS 06 (Grids 06-03, 06-07 and 06-17). Two items were identified as fragmentation; however, nomenclature for the two was not identified due to the small size of the fragments. These two items were recovered in two separate grids (Grids 06-03 and 06-17). Grid 06-03 is located adjacent to residential development, which could be a source for the metallic fragment recovered. No impact areas are historically documented near Grid 06-03. Grid 06-17 is located within the historical buffer areas of Cayo Botella, an adjacent target island located approximately 2,000 yards to the northeast of MRS 06, suggesting a potential source of MD fragments. The other two MD items were identified as artillery primers and were recovered from the same grid (Grid 06-07). The location Grid 06-07 does correlate to historical maneuver or firing point areas as shown on the ASR Supplement (USACE 2005). No MEC or MD items were recovered along the beach areas of MRS 06. The anticipated explosive hazard in MRS 06 is not significant, based on the amount of historical and RI MEC/MD findings. Isolated pieces of munitions fragments may be in the MRS originating from munitions that detonated some distance away, so their presence does not necessarily indicate a significant hazard.

5.3.2 MRS 08 Cayo Norte Impact Area

MRS 08 was leased by the Marines for 75 mm artillery practice. However, it had not been determined from records whether the site was ever used for training.

Figure 5-2 reflects the intrusive results for MRS 08 as shown in Table 4-2. Thirteen MD items were recovered in six grids within MRS 08 (Grids 08-02, 08-03, 08-06, 08-07, 08-08, and 08-09). All 13 MD items were identified to be fragmentation from 75 mm projectiles and are consistent with historical records. Although the anomaly density on MRS 08 is relatively low, there are sufficient amounts of MD to confirm the western side of MRS 08 was used as 75 mm artillery target area, even if for a short period of time. No MEC or MD items were recovered along the beach areas of MRS 08. The presence of MD in the upland areas indicates the possibility of an explosive hazard to be present in MRS 08.

5.3.3 MRS 09 Soldado Point Mortar and Bombing Area

Several training exercises including mortar firing, aerial bombing, and strafing were conducted within MRS 09 during the 1930s and 1940s. Figure 5-3 reflects the intrusive results for MRS 09 as shown in Table 4-2. Seven MD items were recovered in three grids (09-04, 09-07, and 09-13) within MRS 09. No MEC or MD items were recovered along the beach areas of MRS 09. Two MEC items (Mk 25 Marine Marker Flares) were recovered along the surface along the DGM transects located close to the coves. MD recovered from the grid corresponds to 3-inch naval projectiles and 4.2–inch mortar use; however, no MD was recovered that indicated aerial bombing use within MRS 09. Historical documentation indicated use of upland areas for 4.2-inch mortar impact areas. The bombing targets were historically documented as being located within the water areas of Sueno Cove. The presence of MEC and MD in the upland areas indicates the possibility for an explosive hazard to be present in MRS 09.

5.3.4 MRS 10 Defensive Firing Area No. 1

Figure 5-4 shows the areas investigated within MRS 10. Marines conducted amphibious landing and ground maneuver training using 81mm mortars on the beaches and hills in this area from the 1920s through the 1940s. Specifically, the hill on the north end of the MRS has been listed as a 1935 area of direct fire from 3-inch projectiles, and Snug Bay was shown as a 1935 water area for direct fire. Additionally, a 1924 outpost and ammunition storage area was located on the north end of the MRS. No MEC or MD items were recovered within the upland grids or along the beach areas of MRS 10. Intrusive investigations yielded mostly hot rocks or other debris such as fencing, nails, cans, and other non-munitions related debris. The absence of MEC and MD within the investigation areas indicates that historical munitions use, if any, was very limited. Therefore, the anticipated explosive hazard present in MRS 10 is not significant, based on historical findings and no RI MEC/MD findings.MRS 11 DEFENSIVE FIRING AREA NO. 2

Several training exercises were historically documented in MRS 11, including 75mm and 155mm firing from Firewood Bay at Mono Cay (part of MRS 02) and portions of Cayo de Luis Pena (MRS 13) in 1924; firing of small arms and 81mm mortars in 1936; and in boat-to-beach firing of 5-inch and 6-inch projectiles in 1941. The northern portion of MRS 11 is adjacent to the NWP bombardment area, which was the main target area on Culebra. Figure 5-5 reflects the intrusive results for MRS 11 as shown in Table 4-2. Fifteen MD items were recovered from the upland grids (11-13, 11-14, 11-15, 11-16, and 11-17) and two MD items were recovered from beach transects (11M-08 and 11M-11). All of the upland grids containing MD are located within the northern portion of the MRS, which is directly adjacent to the NWP bombardment area. MD from these grids were identified as heavy cased munition fragments, which are indicative of the munitions fired at targets located within the NWP bombardment area. The two MD items located within the beach areas were identified as being an empty 5-inch projectile and a partial BDU-33 practice bomb. The proximity of the beach areas to the NWP bombardment area are also consistent with the type of MD recovered.

The presence of MD in the northern investigation grids and beach areas indicate the possibility for an explosive hazard to be present in the northern portion of MRS 11. However, no MEC or MD items were recovered within the southern portions of MRS 11, as shown in Figure 5-5. The absence of MEC and MD within the southern investigation areas indicates that historical munitions use, if any, was very limited. Therefore, the anticipated explosive hazard present in MRS 11 is not significant, based on the amount of historical and RI MEC/MD findings.

5.3.5 MRS 13 Cayo Luis Pena Impact Areas

Several training exercises were historically documented in MRS 13. The northern tip of this island was used as a firing target during Marine exercises conducted between 1924 and 1941. Records show that 75mm projectiles were fired at the northern tip of MRS 13 in 1924 and that 155mm, 37mm, 8-inch, and 6-inch projectiles may have also been used. In the 1960s, an observation point was erected on the hilltop on Luis Pena, including a run-in line, helipad, and living quarters. A TPP decision was made to not conduct vegetation removal in order to conduct DGM surveys on MRS 13; therefore, the RI investigations conducted on MRS 13 were limited to analog mag-and-dig investigations along established trails and within the beach areas. The investigation in this MRS is augmented with visual surface reconnaissance from a 2009 post award site visit. Figure 5-6 reflects the RI intrusive results for MRS 13, as shown in Table 4-2. The RI recovered ten MD items and two MD items from expended small arms ammunition were

recovered on MRS 13 beach areas. A majority of these items were recovered on the northern portion of MRS 13. During the 2009 site visit, there were observations of MD from 105mm projectiles (1-HE, 1-illumination, 4-unidentified), 5-inch projectiles (31), 3-inch projectiles (3), flares (8), fuzes, and other MD pieces. The northern area of MRS 13 is located behind the range fans associated with the NWP bombardment area, thus having the possibility of receiving overshoots from that range (3-inch to 8-inch projectiles). The majority of MD recovered in this area consisted of empty 5-inch illumination projectiles. These items are consistent with the types of naval gunnery practice conducted within the NWP bombardment area.

The ASR Supplement (USACE, 2005) shows the northern tip of MRS 13 as a 1924 75mm and 155mm target area. This area is inaccessible due to extremely steep terrain and heavy vegetation; thus, no RI investigations were conducted within this area. In addition, MD related to 75mm or 155mm use was not recovered around the adjacent beach areas. One partial BDU-33 practice bomb was recovered in one of the digs on beach transect 13M-13. The beach in which this was recovered is within the run-in line for a bombing target located on Agua Cay, located to the northwest of this beach area. It is believed that the recovered BDU-33 may be a short that was dropped on MRS 13. The presence of MD in the beach areas indicates the possibility of an explosive hazard to be present in MRS 13.

5.4 MUNITIONS CONSTITUENTS (MC)

As outlined in the RI WP, a phased baseline risk assessment approach was employed starting with the evaluation and identification of preliminary contaminants of potential concern (PCOPCs) for each site to determine COPCs that would then be evaluated further. To determine if a PCOPC should be considered a COPC, each PCOPC was evaluated using several criteria. For an analyte to be considered contamination related to a release from munitions-related activities at the site (i.e., COPC), it is necessary for the following conditions to be true.

- The analyte is detected in the sample medium.
- The analyte is a potential constituent of the munitions formerly used at the site.
- The analyte is present at concentrations greater than the selected PSVs.

Each PCOPC was evaluated using these criteria to determine whether or not potential contamination is present at the site. The maximum detected concentrations of analytes at each site were compared to PSVs in the Source Evaluation Tables (see Chapter 7). Only PCOPCs that met the conditions noted above were considered COPCs and were evaluated further in the risk assessment. Tables containing the laboratory analytical results are presented in Appendix B of this document. The analytical results for the individual sites are evaluated separately.

5.4.1 MC Characterization Data

An evaluation of the analytical data for each MRS at Culebra Island site used to characterize the presence of MC in environmental media is presented in the following sections. The evaluation determined whether there was evidence of a release of contaminants at each MRS and identified COPCs requiring further consideration in the risk assessment process. No MC samples were collected in MRS 10 since no MEC or MD was recovered during the intrusive investigations. Therefore no MC Characterization activities were conducted in MRS 10.

5.4.1.1 MRS 06 North

Surface Soil

In support of the RI, one surface soil sample (PR-1014-S-084) was collected within DeE2 soils at MRS 06N and analyzed for explosives and nine MC metals. Following evaluation of this initial sample, an additional 13 step-out samples (PR-0212-S-001 through PR-0212-S-013) were collected surrounding this sample location to characterize the potential release of barium to surface soil at this location. The step-out samples were analyzed for barium only. The analytical results are presented in Appendix B.

The maximum detected concentration of each analyte detected in surface soil is compared to PSVs in Table 5-1. The maximum detected concentration of barium (1,100 mg/kg) was detected above its PSV (710 mg/kg); therefore, barium is considered a COPC and was retained for further consideration.

Surface Water and Sediment

No perennial surface water is present, therefore surface water and sediment were not evaluated in the RI.

Groundwater

To evaluate the potential risk associated with groundwater in the northern portion of MRS 06, one groundwater sample (PR-CUL-GW-MRS-06-6) was collected from an existing well identified as Well 6-6 (Figure 4-13) and analyzed for explosives, ammonium picrate, eight MC metals, perchlorate, chloride, and nitrate/nitrite as N. The analytical results are presented in Appendix B.

The maximum detected concentration of each analyte is compared to PSVs (if available) in Table 5-2. Explosives were not detected in any of the groundwater samples collected at MRS 06N. None of the other PCOPCs exceeded PSVs at site MRS 06N.

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Table 5-1: Soil Source Evaluation MRS 06 NORTH

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330									
1,3,5-Trinitrobenzene	mg/kg	0.08	U	DeE2	Yes	0.38	No	No	Not detected at MRS
1,3-Dinitrobenzene	mg/kg	0.08	U	DeE2	Yes	0.61	No	No	Not detected at MRS
2,4,6-Trinitrobenzene	mg/kg	0.08	U	DeE2	Yes	6.4	No	No	Not detected at MRS
2,4-Dinitrotoluene	mg/kg	0.08	U	DeE2	Yes	1.3	No	No	Not detected at MRS
2,6-Dinitrotoluene	mg/kg	0.08	U	DeE2	Yes	0.033	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	mg/kg	0.08	U	DeE2	Yes	10	No	No	Not detected at MRS
2-Nitrotoluene	mg/kg	0.08	U	DeE2	Yes	2.9	No	No	Not detected at MRS
3-Nitrotoluene	mg/kg	0.08	U	DeE2	Yes	0.61	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	mg/kg	0.08	U	DeE2	Yes	3.6	No	No	Not detected at MRS
4-Nitrotoluene	mg/kg	0.08	U	DeE2	Yes	22	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine	mg/kg	0.08	U	DeE2	Yes	5.6	No	No	Not detected at MRS
Nitrobenzene	mg/kg	0.08	U	DeE2	Yes	1.3	No	No	Not detected at MRS
Nitrogylcerin	mg/kg	0.16	U	DeE2	Yes	0.61	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	mg/kg	0.08	U	DeE2	Yes	27	No	No	Not detected at MRS
PETN	mg/kg	0.4	U	DeE2	Yes	100	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	mg/kg	0.08	U	DeE2	Yes	0.99	No	No	Not detected at MRS

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Metals - SW6020A/SW3050B									
Aluminum	mg/kg	27,000		DeE2	Yes	55,000	No	No	Does not exceed PSV
Barium	mg/kg	1,100		DeE2	Yes	710	Yes	Yes	--
Chromium	mg/kg	13		DeE2	Yes	26	No	No	Does not exceed PSV
Copper	mg/kg	310		DeE2	Yes	360	No	No	Does not exceed PSV
Lead	mg/kg	19		DeE2	Yes	98	No	No	Does not exceed PSV
Zinc	mg/kg	200		DeE2	Yes	350	No	No	Does not exceed PSV
Antimony	mg/kg	0.16	J	DeE2	Yes	1.2	No	No	Does not exceed PSV
Mercury	mg/kg	0.033		DeE2	Yes	0.1	No	No	Does not exceed PSV

U = undetected at the stated reporting limit.

J = Estimated concentration

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Table 5-2: Groundwater Source Evaluation MRS 06 NORTH (PR-CUL-GW-MRS-06-6)

Analyte	Units	Maximum Detected Concentration		Potential MC?	Preliminary Screening Values (PSV) [1]	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330B								
1,3,5-Trinitrobenzene	µg/L	0.30	U	Yes	46	No	No	Not detected at MRS
1,3-Dinitrobenzene	µg/L	0.30	U	Yes	0.15	No	No	Not detected at MRS
2,4,6-Trinitrotoluene (TNT)	µg/L	0.30	U	Yes	0.76	No	No	Not detected at MRS
2,4-Dinitrotoluene	µg/L	0.30	U	Yes	0.20	No	No	Not detected at MRS
2,6-Dinitrotoluene	µg/L	0.30	U	Yes	0.042	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	µg/L	0.30	U	Yes	3.0	No	No	Not detected at MRS
2-Nitrotoluene	µg/L	0.30	U	Yes	0.27	No	No	Not detected at MRS
3-Nitrotoluene	µg/L	0.30	U	Yes	0.13	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	µg/L	0.30	U	Yes	3.0	No	No	Not detected at MRS
4-Nitrotoluene	µg/L	0.30	U	Yes	3.7	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	µg/L	0.30	U	Yes	0.61	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	µg/L	0.30	U	Yes	3.1	No	No	Not detected at MRS
Nitrobenzene	µg/L	0.30	U	Yes	0.12	No	No	Not detected at MRS
Nitroglycerin	µg/L	0.30	U	Yes	0.15	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	µg/L	0.30	U	Yes	78	No	No	Not detected at MRS
Pentaerythritol Tetranitrate (PETN)	µg/L	1.5	U	Yes	3.0	No	No	Not detected at MRS
Ammonium Picrate - SW8321A								
Ammonium picrate	µg/L	0.12	U	Yes	NA	No	No	Not detected at MRS
Total Metals - SW/7470A								
Aluminum	µg/L	24	B	Yes	1,600	No	No	Detected in equipment blank [2]
Antimony	µg/L	0.50	U	Yes	0.60	No	No	Not detected at MRS
Barium	µg/L	63		Yes	290	No	No	Does not exceed PSV

Analyte	Units	Maximum Detected Concentration		Potential MC?	Preliminary Screening Values (PSV) [1]	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Chromium(total)	µg/L	0.14	B	Yes	NA	No	No	Detected in equipment blank [2]
Chromium(III) [3]	µg/L	N/A [2]		Yes	1,600	No	No	Detected in equipment blank [2]
Chromium(Vl) [3]	µg/L	N/A [2]		Yes	0.031	No	No	Detected in equipment blank [2]
Copper	µg/L	8.6		Yes	62	No	No	Does not exceed PSV
Lead	µg/L	0.22	J	Yes	15	No	No	Does not exceed PSV
Mercury	µg/L	0.10	B	Yes	0.43	No	No	Detected in equipment blank [2]
Zinc	µg/L	32		Yes	470	No	No	Does not exceed PSV
Perchlorate - SW6850								
Perchlorate	µg/L	0.40	U	Yes	1.1	No	No	Not detected at MRS

(NO CODE) - Confirmed identification.

U - Analyte was analyzed for but not detected above the limit of detection (LOD).

J - Analyte detected, estimated concentration.

NA - Screening criterion not available

N/A - Not Applicable

(1) USEPA Regional Screening Levels (RSLs) for Tapwater (Target Risk = 10-6; Hazard Quotient = 0.1), November 2013. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/docs/master_sl_table_01run_NOV2013.pdf)

(2) B qualified data were treated as nondetected chemicals because the chemical was detected in the associated blank and the estimated chemical concentration in the sample was not five times greater than the concentration in the associated blank (RAGS A, USEPA, 1989).

(3) Chromium can exist in the environment as chromium (III) and chromium (VI). The analytical results presented in this report are for chromium (total) and do not distinguish between the different valence states. It is assumed that total chromium is composed of chromium (VI) and chromium (III) in a 1 to 6 ratio. The estimated chromium (VI) concentration is calculated by dividing the maximum chromium (total) concentration measured in soil samples by 7. For the site concentration, the maximum chromium (total) concentration is 1.5 µg/L. Therefore, the estimated chromium(VI) concentration is 0.21 µg/L and the chromium(III) concentration is estimated as 1.3 µg/L.

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5.4.1.2 MRS 06 South

Surface Soil

In support of the RI, two surface soil samples were collected from MRS 06S. One surface soil sample (PR-1014-S-083) was collected from DeE2 soils and one surface soil sample (PR-1014-S-082) was collected from Rs soils. Both samples were analyzed for explosives and nine MC metals. The analytical results are presented in Appendix B. Additionally, two soil samples from this area were collected and analyzed for the 2007 SI and those results were considered in this assessment. These samples were collected from Rs soils.

The maximum detected concentration of each analyte detected in surface soil is compared to respective PSVs in Table 5-3. Explosives were not detected in any of the soil samples collected at MRS 06S. Therefore, explosives were not retained for further consideration in this risk assessment. The maximum detected concentration of all nine metals did not exceed their respective PSVs at MRS 06S. With the exception of antimony, chromium, and lead, the maximum detected concentrations of metals at MRS 06S were in samples collected in DeE2 soils. However, the maximum detected concentrations of metals in samples collected in Rs soils, including antimony, chromium, and lead, at this MRS also did not exceed their respective PSVs. Therefore, metals were not retained for further consideration in this human health or ecological risk assessment.

Surface Water

No surface water sampling was conducted in MRS 06 South due to no MEC findings and the low density of MD indicating no evidence of concentrated munitions use.

Groundwater

To evaluate the potential risk associated with exposure to groundwater in the southern portion of MRS 06, one groundwater sample (PR-CUL-GW-MRS-06-9, and duplicate PR-CUL-GW-MRS-06-10) were collected from an existing well at MRS 06S and analyzed for explosives, ammonium picrate, eight MC metals, perchlorate, chloride, and nitrate/nitrite as N. The analytical results are presented in Appendix B.

The maximum detected concentration of each analyte is compared to PSVs (if available) in Table 5-4. Explosives were not detected in any of the groundwater samples at MRS 06. The estimated maximum concentration of chromium (VI) (0.21 µg/L), which is equal to the maximum detected total chromium concentration divided by seven, exceeded its PSV (0.031 µg/L). Therefore, chromium will be further evaluated in the risk assessment.

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Table 5-3: Soil Source Evaluation MRS 06 South

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330									
1,3,5-Trinitrobenzene	mg/kg	0.08	U	Rs	Yes	0.38	No	No	Not detected at MRS
1,3-Dinitrobenzene	mg/kg	0.08	U	Rs	Yes	0.61	No	No	Not detected at MRS
2,4,6-Trinitrobenzene	mg/kg	0.08	U	Rs	Yes	6.4	No	No	Not detected at MRS
2,4-Dinitrotoluene	mg/kg	0.08	U	Rs	Yes	1.3	No	No	Not detected at MRS
2,6-Dinitrotoluene	mg/kg	0.08	U	Rs	Yes	0.033	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	mg/kg	0.08	U	Rs	Yes	10	No	No	Not detected at MRS
2-Nitrotoluene	mg/kg	0.08	U	Rs	Yes	2.9	No	No	Not detected at MRS
3-Nitrotoluene	mg/kg	0.08	U	Rs	Yes	0.61	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	mg/kg	0.08	U	Rs	Yes	3.6	No	No	Not detected at MRS
4-Nitrotoluene	mg/kg	0.08	U	Rs	Yes	22	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine	mg/kg	0.08	U	Rs	Yes	5.6	No	No	Not detected at MRS
Nitrobenzene	mg/kg	0.08	U	Rs	Yes	1.3	No	No	Not detected at MRS
Nitrogylcerin	mg/kg	0.16	U	Rs	Yes	0.61	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	mg/kg	0.08	U	Rs	Yes	27	No	No	Not detected at MRS
PETN	mg/kg	0.4	U	Rs	Yes	100	No	No	Not detected at MRS

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Methyl-2,4,6-trinitro-phenylnitramine (tetryl)	mg/kg	0.08	U	Rs	Yes	0.99	No	No	Not detected at MRS
Metals - SW6020A/SW3050B									
Aluminum	mg/kg	32,000		DeE2	Yes	55,000	No	No	Does not exceed PSV
Barium	mg/kg	350		DeE2	Yes	710	No	No	Does not exceed PSV
Chromium	mg/kg	19 (1)		Rs	Yes	34	No	No	Does not exceed PSV
Copper	mg/kg	230		DeE2	Yes	360	No	No	Does not exceed PSV
Iron	mg/kg	67,000		DeE2	Yes	120,000	No	No	Does not exceed PSV
Lead	mg/kg	15 (1)		Rs	Yes	220	No	No	Does not exceed PSV
Zinc	mg/kg	100		DeE2	Yes	350	No	No	Does not exceed PSV
Antimony	mg/kg	0.160		Rs	Yes	1.3	No	No	Does not exceed PSV
Mercury	mg/kg	0.048		DeE2	Yes	0.1	No	No	Does not exceed PSV
U = Undetected at the stated reporting limit.									
(1) - Maximum detected concentration is from the 2007 SI Report (Parsons, 2007)									

2660 **Table 5-4: Groundwater Source Evaluation MRS 06 South (PR-CUL-GW-MRS-06-9 and duplicate PR-CUL-GW-MRS-06-10)**

Analyte	Units	Maximum Detected Concentration		Potential MC?	Preliminary Screening Values (PSV) [1]	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330B								
1,3,5-Trinitrobenzene	µg/L	0.30	U	Yes	46	No	No	Not detected at MRS
1,3-Dinitrobenzene	µg/L	0.30	U	Yes	0.15	No	No	Not detected at MRS
2,4,6-Trinitrotoluene (TNT)	µg/L	0.30	U	Yes	0.76	No	No	Not detected at MRS
2,4-Dinitrotoluene	µg/L	0.30	U	Yes	0.20	No	No	Not detected at MRS
2,6-Dinitrotoluene	µg/L	0.30	U	Yes	0.042	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	µg/L	0.30	U	Yes	3.0	No	No	Not detected at MRS
2-Nitrotoluene	µg/L	0.30	U	Yes	0.27	No	No	Not detected at MRS
3-Nitrotoluene	µg/L	0.30	U	Yes	0.13	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	µg/L	0.30	U	Yes	3.0	No	No	Not detected at MRS
4-Nitrotoluene	µg/L	0.30	U	Yes	3.7	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	µg/L	0.30	U	Yes	0.61	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	µg/L	0.30	U	Yes	3.1	No	No	Not detected at MRS
Nitrobenzene	µg/L	0.30	U	Yes	0.12	No	No	Not detected at MRS
Nitroglycerin	µg/L	0.30	U	Yes	0.15	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	µg/L	0.30	U	Yes	78	No	No	Not detected at MRS
Pentaerythritol Tetranitrate (PETN)	µg/L	1.5	U	Yes	3.0	No	No	Not detected at MRS
Ammonium Picrate - SW8321A								
Ammonium picrate	µg/L	0.12	U	Yes	NA	No	No	Not detected at MRS
Total Metals - SW/7470A								
Aluminum	µg/L	18	B	Yes	1,600	No	No	Detected in equipment blank [2]
Antimony	µg/L	0.19	J	Yes	0.60	No	No	Does not exceed PSV

Analyte	Units	Maximum Detected Concentration		Potential MC?	Preliminary Screening Values (PSV) [1]	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Barium	µg/L	78		Yes	290	No	No	Does not exceed PSV
Chromium(total)	µg/L	1.5		Yes	NA	N/A	N/A	N/A
Chromium(III) [3]	µg/L	1.3		Yes	1,600	No	No	Does not exceed PSV
Chromium(VI) [3]	µg/L	0.21		Yes	0.031	**Yes**	--	--
Copper	µg/L	19	J	Yes	62	No	No	Does not exceed PSV
Lead	µg/L	0.26	J	Yes	15	No	No	Does not exceed PSV
Mercury	µg/L	0.071	B	Yes	0.43	No	No	Detected in equipment blank [2]
Zinc	µg/L	330	J	Yes	470	No	No	Does not exceed PSV
Perchlorate - SW6850								
Perchlorate	µg/L	1.1	J	Yes	1.1	No	No	Does not exceed PSV

(NO CODE) - Confirmed identification.

U - Analyte was analyzed for but not detected above the limit of detection (LOD).

J - Analyte detected, estimated concentration.

NA - Screening criterion not available

N/A - Not Applicable

(1) USEPA Regional Screening Levels (RSLs) for Tapwater (Target Risk = 10-6; Hazard Quotient = 0.1), November 2013. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/docs/master_sl_table_01run_NOV2013.pdf)

(2) B qualified data were treated as nondetected chemicals because the chemical was detected in the associated blank and the estimated chemical concentration in the sample was not five times greater than the concentration in the associated blank (RAGS A, USEPA, 1989).

(3) Chromium can exist in the environment as chromium (III) and chromium (VI). The analytical results presented in this report are for chromium (total) and do not distinguish between the different valence states. It is assumed that total chromium is composed of chromium (VI) and chromium (III) in a 1 to 6 ratio. The estimated chromium (VI) concentration is calculated by dividing the maximum chromium (total) concentration measured in soil samples by 7. For the site concentration, the maximum chromium (total) concentration is 1.5 µg/L. Therefore, the estimated chromium(VI) concentration is 0.21 µg/L and the chromium(III) concentration is estimated as 1.3 µg/L.

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5.4.1.3 MRS 08

Surface Soil

In support of the RI, a total of 12 surface soil samples were collected from MRS 08. Two surface soil samples (PR-1013-S-070 and PR-1013-S-073) were collected within DeE2 soils and 10 surface soil samples (PR-1013-S-071, PR-1013-S-072, and PR-1013-S-074 through PR-1013-S-081) were collected within DrF soils. All samples were analyzed for explosives and nine metals. The analytical results are presented in Appendix B. Additionally, two soil samples from this area were collected and analyzed in the 2007 SI and those results were considered in this assessment.

The maximum detected concentration of each analyte detected in surface soil is compared to PSVs in Table 5-5. Explosives were not detected in any of the soil samples collected at MRS 08. Therefore, explosives were not retained for further consideration in this risk assessment. The maximum detected concentration of all nine metals did not exceed their respective PSVs at MRS 08. The maximum detected concentrations of metals at MRS 08 were in samples collected in DrF soils. However, the maximum detected concentrations of metals in samples collected in DeE2 soils at this MRS also did not exceed their respective PSVs. Therefore, metals were not retained for further consideration in this human health or ecological risk assessment.

Surface Water

No surface water samples were collected from this MRS during the RI because no perennial water source was present. As a result, the surface water exposure pathway is incomplete and is not considered further in this risk assessment.

Sediment

One sediment sample was collected and analyzed during the 2007 SI. The sediment is composed of DrF soil type. Six metals–barium, chromium, copper, lead, zinc, and mercury–were detected and retained for evaluation in the SI. The 2007 sampling event was conducted after considerable rain events; however, during the 2011 RI sampling event the surface water was no longer present. No sediment or surface water samples were collected from this MRS during the RI because no perennial water source was present. As a result, the sediment/surface water exposure pathway is incomplete and is not considered further in this risk assessment. Therefore, the 2007 sediment data are considered in this RI as soil data. As such, none of the concentrations of metals detected in the 2007 sample exceed their PSVs. Based on the results of SI and RI sampling at MRS 08 metals were not retained for further consideration in this risk assessment.

Groundwater

No wells are present on MRS 08, and there is no evidence groundwater has been used as a source of potable water. There are currently no permanent residences on the island. Given the impermeable nature of the volcanic rock with storage located within fracturing, the small acreage of the island that would significantly be impacted by saltwater intrusion, and the logistical challenges to deliver drilling equipment to the island, it is unlikely wells will be drilled in the future. Therefore, the groundwater pathway is considered incomplete.

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Table 5-5: Soil Source Evaluation MRS 08

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330									
1,3,5-Trinitrobenzene	mg/kg	0.08	U	DrF	Yes	0.38	No	No	Not detected at MRS
1,3-Dinitrobenzene	mg/kg	0.08	U	DrF	Yes	0.61	No	No	Not detected at MRS
2,4,6-Trinitrobenzene	mg/kg	0.08	U	DrF	Yes	6.4	No	No	Not detected at MRS
2,4-Dinitrotoluene	mg/kg	0.08	U	DrF	Yes	1.3	No	No	Not detected at MRS
2,6-Dinitrotoluene	mg/kg	0.08	U	DrF	Yes	0.033	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	mg/kg	0.08	U	DrF	Yes	10	No	No	Not detected at MRS
2-Nitrotoluene	mg/kg	0.08	U	DrF	Yes	2.9	No	No	Not detected at MRS
3-Nitrotoluene	mg/kg	0.08	U	DrF	Yes	0.61	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	mg/kg	0.08	U	DrF	Yes	3.6	No	No	Not detected at MRS
4-Nitrotoluene	mg/kg	0.08	U	DrF	Yes	22	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine	mg/kg	0.08	U	DrF	Yes	5.6	No	No	Not detected at MRS
Nitrobenzene	mg/kg	0.08	U	DrF	Yes	1.3	No	No	Not detected at MRS
Nitrogylcerin	mg/kg	0.16	U	DrF	Yes	0.61	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	mg/kg	0.08	U	DrF	Yes	27	No	No	Not detected at MRS
PETN	mg/kg	0.4	U	DrF	Yes	100	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	mg/kg	0.08	U	DrF	Yes	0.99	No	No	Not detected at MRS

Analyte	Units	Maximum Detected Concentration	Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Metals - SW6020A/SW3050B								
Aluminum	mg/kg	31,000	DrF	Yes	56,000	No	No	Does not exceed PSV
Barium	mg/kg	290	DrF	Yes	430	No	No	Does not exceed PSV
Chromium	mg/kg	3.1	DrF	Yes	30	No	No	Does not exceed PSV
Copper	mg/kg	43	DrF	Yes	140	No	No	Does not exceed PSV
Iron	mg/kg	69,000	DrF	Yes	120,000	No	No	Does not exceed PSV
Lead	mg/kg	13	DrF	Yes	17	No	No	Does not exceed PSV
Zinc	mg/kg	110	DrF	Yes	220	No	No	Does not exceed PSV
Antimony	mg/kg	0.190 J	DrF	Yes	0.30	No	No	Does not exceed PSV
Mercury	mg/kg	0.066	DrF	Yes	0.1	No	No	Does not exceed PSV

U = undetected at the stated reporting limit.

J = Estimated concentration

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5.4.1.4 MRS 09

Surface Soil

In support of the RI, six surface soil samples (PR-1012-S-029 through PR-1012-S-034) were collected from Rs soils at MRS 09 and were analyzed for explosives and nine metals. Four post-detonation samples (PR-0013-CPST through PR-0016-CPST) were also collected at a consolidation location where marine flares found at MRS 09 and items from other MRSs were detonated; these four post-detonation samples were analyzed for explosives only. The analytical results are presented in Appendix B. Additionally, two soil samples from this area were collected and analyzed in the 2007 SI and those results were considered in this assessment.

The maximum detected concentration of each analyte is compared to PSVs in Table 5-6. Explosives were not detected in any of the soil samples collected at MRS 09. Therefore, explosives were not retained for further consideration in this risk assessment. The maximum detected concentration of all nine metals did not exceed their respective PSVs at MRS 09. Therefore, metals in surface soil were not retained for further consideration in this risk assessment.

Surface Water

In support of the RI, three surface water samples (PR-1012-SW-035 through PR-1012-SW-037) were collected at MRS 09. All samples were analyzed for explosives and nine MC metals. The analytical results are presented in Appendix B. No surface water samples were collected during the 2007 SI; only surface water sampling results from the RI were used for this assessment.

The maximum detected concentration of each analyte is compared to PSVs in Table 5-7. Explosives were not detected in any of the surface water samples collected at MRS 09. Therefore, explosives were not retained for further consideration in this risk assessment. The maximum detected concentration of all nine metals did not exceed their respective surface water PSVs at MRS 09. Therefore, metals in surface water were not retained for further consideration in this risk assessment.

Sediment

In support of the RI, two sediment samples (PR-1012-SD-035 and PR-1012-SD-037) were collected at MRS 09. The sediment at this site is composed of Rs soils. Both samples were analyzed for explosives and nine metals. The analytical results are presented in Appendix B. No sediment samples were collected during the 2007 SI; only sediment sampling results from the RI were used for this assessment.

The maximum detected concentration of each analyte is compared to PSVs in Table 5-8. Explosives were not detected in any of the sediment samples collected at MRS 09. Therefore, explosives were not retained for further consideration in this risk assessment. The maximum detected concentration of seven metals (barium, chromium, iron, lead, zinc, antimony, and mercury) did not exceed their respective PSVs at MRS 09. The maximum detected concentrations of aluminum (68,000 mg/kg) and copper (390 mg/kg) were greater than their respective PSVs (57,000 and 310 mg/kg). Since sediment at MRS 09 was sampled in a small collection lagoon that does not have an outfall or discharge in any way to other surface water bodies, no additional sediment samples were collected to delineate aluminum and copper in

sediment. Therefore, aluminum and copper are considered COPCs in sediment and were retained for further consideration in this risk assessment.

Groundwater

To evaluate potential risk associated with exposure to groundwater in MRS 09, one groundwater sample (PR-CUL-GW-MRS-09-3 was collected from a newly installed monitoring well at MRS 09 and analyzed for explosives, ammonium picrate, eight MC metals, perchlorate, chloride, and nitrate/nitrite as N. The analytical results are presented in Appendix B.

The maximum detected concentration of each analyte is compared to PSVs (if available) in Table 5-1. Explosives were not detected in any of the groundwater samples collected at MRS 09. The maximum detected concentration of copper (140 µg/L) was greater than its PSV (62 µg/L). The estimated maximum concentration of chromium (VI) (0.036 µg/L), which is equal to the maximum detected total chromium concentration divided by seven, exceeded its PSV (0.031 mg/kg). Copper and chromium will be retained for further consideration in the risk assessment.

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Table 5-6: Soil Source Evaluation MRS 09

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330									
1,3,5-Trinitrobenzene	mg/kg	0.08	U	Rs	Yes	0.38	No	No	Not detected at MRS
1,3-Dinitrobenzene	mg/kg	0.08	U	Rs	Yes	0.61	No	No	Not detected at MRS
2,4,6-Trinitrobenzene	mg/kg	0.08	U	Rs	Yes	6.4	No	No	Not detected at MRS
2,4-Dinitrotoluene	mg/kg	0.08	U	Rs	Yes	1.3	No	No	Not detected at MRS
2,6-Dinitrotoluene	mg/kg	0.08	U	Rs	Yes	0.033	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	mg/kg	0.08	U	Rs	Yes	10	No	No	Not detected at MRS
2-Nitrotoluene	mg/kg	0.08	U	Rs	Yes	2.9	No	No	Not detected at MRS
3-Nitrotoluene	mg/kg	0.08	U	Rs	Yes	0.61	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	mg/kg	0.08	U	Rs	Yes	3.6	No	No	Not detected at MRS
4-Nitrotoluene	mg/kg	0.08	U	Rs	Yes	22	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine	mg/kg	0.08	U	Rs	Yes	5.6	No	No	Not detected at MRS
Nitrobenzene	mg/kg	0.08	U	Rs	Yes	1.3	No	No	Not detected at MRS
Nitrogylcerin	mg/kg	0.16	U	Rs	Yes	0.61	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	mg/kg	0.08	U	Rs	Yes	27	No	No	Not detected at MRS
PETN	mg/kg	0.4	U	Rs	Yes	100	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	mg/kg	0.08	U	Rs	Yes	0.99	No	No	Not detected at MRS

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Metals - SW6020A/SW3050B									
Aluminum	mg/kg	43,000		Rs	Yes	57,000	No	No	Does not exceed PSV
Barium	mg/kg	360		Rs	Yes	960	No	No	Does not exceed PSV
Chromium	mg/kg	19 (1)		Ts	Yes	26	No	No	Does not exceed PSV
Copper	mg/kg	190		Rs	Yes	310	No	No	Does not exceed PSV
Lead	mg/kg	8.8 (1)		Ts	Yes	18	No	No	Does not exceed PSV
Zinc	mg/kg	82		Rs	Yes	500	No	No	Does not exceed PSV
Antimony	mg/kg	0.083	J	Rs	Yes	1.3	No	No	Does not exceed PSV
Mercury	mg/kg	0.094		Rs	Yes	0.60	No	No	Does not exceed PSV

U = undetected at the stated reporting limit.
J = Estimated concentration

(1) Maximum detected concentrations from the 2007 SI Report (Parsons, 2007)

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Table 5-7: Surface Water Source Evaluation MRS 09

Analyte	Units	Maximum Detected Concentration		Potential MC?	Preliminary Screening Values (PSV)	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Metals - SW6020A/SW3050B								
Aluminum	µg/L	910		Yes	1,700	No	No	Does not exceed PSV
Barium	µg/L	17		Yes	360	No	No	Does not exceed PSV
Chromium	µg/L	0.38		Yes	120	No	No	Does not exceed PSV
Copper	µg/L	9		Yes	30	No	No	Does not exceed PSV
Lead	µg/L	0.2		Yes	1.3	No	No	Does not exceed PSV
Zinc	µg/L	5		Yes	59	No	No	Does not exceed PSV
Antimony	µg/L	2	J	Yes	3.5	No	No	Does not exceed PSV
Mercury	µg/L	0.2	U	Yes	0.012	No	No	Not detected at MRS

U = undetected at the stated reporting limit.

J = Estimated concentration

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Table 5-8: Sediment Source Evaluation MRS 09

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330									
1,3,5-Trinitrobenzene	mg/kg	0.079	U	Rs	Yes	0.38	No	No	Not detected at MRS
1,3-Dinitrobenzene	mg/kg	0.079	U	Rs	Yes	0.61	No	No	Not detected at MRS
2,4,6-Trinitrobenzene	mg/kg	0.079	U	Rs	Yes	6.4	No	No	Not detected at MRS
2,4-Dinitrotoluene	mg/kg	0.079	U	Rs	Yes	1.3	No	No	Not detected at MRS
2,6-Dinitrotoluene	mg/kg	0.079	U	Rs	Yes	0.033	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	mg/kg	0.079	U	Rs	Yes	10	No	No	Not detected at MRS
2-Nitrotoluene	mg/kg	0.079	U	Rs	Yes	2.9	No	No	Not detected at MRS
3-Nitrotoluene	mg/kg	0.079	U	Rs	Yes	0.61	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	mg/kg	0.079	U	Rs	Yes	3.6	No	No	Not detected at MRS
4-Nitrotoluene	mg/kg	0.079	U	Rs	Yes	22	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine	mg/kg	0.079	U	Rs	Yes	5.6	No	No	Not detected at MRS
Nitrobenzene	mg/kg	0.079	U	Rs	Yes	1.3	No	No	Not detected at MRS
Nitrogylcerin	mg/kg	0.16	U	Rs	Yes	0.61	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	mg/kg	0.079	U	Rs	Yes	27	No	No	Not detected at MRS
PETN	mg/kg	0.39	U	Rs	Yes	100	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	mg/kg	0.079	U	Rs	Yes	0.99	No	No	Not detected at MRS

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Metals - SW6020A/SW3050B									
Aluminum	mg/kg	68,000		Rs	Yes	57,000	**Yes**	**Yes**	--
Barium	mg/kg	470		Rs	Yes	960	No	No	Does not exceed PSV
Chromium	mg/kg	20		Rs	Yes	34	No	No	Does not exceed PSV
Copper	mg/kg	390		Rs	Yes	310	**Yes**	**Yes**	--
Lead	mg/kg	18		Rs	Yes	220	No	No	Does not exceed PSV
Zinc	mg/kg	160		Rs	Yes	500	No	No	Does not exceed PSV
Antimony	mg/kg	0.320	J	Rs	Yes	1.3	No	No	Does not exceed PSV
Mercury	mg/kg	0.068		Rs	Yes	0.60	No	No	Does not exceed PSV

U = undetected at the stated reporting limit.

J = Estimated concentration

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Table 5-9: Groundwater Source Evaluation MRS 09

Analyte	Units	Maximum Detected Concentration		Potential MC?	Preliminary Screening Values (PSV) [1]	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330B								
1,3,5-Trinitrobenzene	µg/L	0.30	U	Yes	46	No	No	Not detected at MRS
1,3-Dinitrobenzene	µg/L	0.30	U	Yes	0.15	No	No	Not detected at MRS
2,4,6-Trinitrotoluene (TNT)	µg/L	0.30	U	Yes	0.76	No	No	Not detected at MRS
2,4-Dinitrotoluene	µg/L	0.30	U	Yes	0.20	No	No	Not detected at MRS
2,6-Dinitrotoluene	µg/L	0.30	U	Yes	0.042	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	µg/L	0.30	U	Yes	3.0	No	No	Not detected at MRS
2-Nitrotoluene	µg/L	0.30	U	Yes	0.27	No	No	Not detected at MRS
3-Nitrotoluene	µg/L	0.30	U	Yes	0.13	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	µg/L	0.30	U	Yes	3.0	No	No	Not detected at MRS
4-Nitrotoluene	µg/L	0.30	U	Yes	3.7	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	µg/L	0.30	U	Yes	0.61	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	µg/L	0.30	U	Yes	3.1	No	No	Not detected at MRS
Nitrobenzene	µg/L	0.30	U	Yes	0.12	No	No	Not detected at MRS
Nitroglycerin	µg/L	0.30	U	Yes	0.15	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	µg/L	0.30	U	Yes	78	No	No	Not detected at MRS
Pentaerythritol Tetranitrate (PETN)	µg/L	1.5	U	Yes	3.0	No	No	Not detected at MRS
Ammonium Picrate - SW8321A								
Ammonium picrate	µg/L	0.12	U	Yes	NA	No	No	Not detected at MRS
Total Metals - SW/7470A								
Aluminum	µg/L	42	B	Yes	1,600	No	No	Detected in equipment blank [2]

Analyte	Units	Maximum Detected Concentration	Potential MC?	Preliminary Screening Values (PSV) (1)	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Antimony	µg/L	0.26 J	Yes	0.60	No	No	Does not exceed PSV
Barium	µg/L	39	Yes	290	No	No	Does not exceed PSV
Chromium(total)	µg/L	0.25 J	Yes	NA	N/A	N/A	N/A
Chromium(III) (3)	µg/L	0.21	Yes	1,600	No	No	Does not exceed PSV
Chromium(VI) (3)	µg/L	0.036	Yes	0.031	Yes	**Yes**	--
Copper	µg/L	140	Yes	62	Yes	**Yes**	--
Lead	µg/L	1.2	Yes	15	No	No	Does not exceed PSV
Mercury	µg/L	0.15 U	Yes	0.43	No	No	Not detected at MRS
Zinc	µg/L	110	Yes	470	No	No	Does not exceed PSV
Perchlorate - SW6850							
Perchlorate	µg/L	0.40 U	Yes	1.1	No	No	Not detected at MRS

(NO CODE) - Confirmed identification.

U - Analyte was analyzed for but not detected above the limit of detection (LOD).

J - Analyte detected, estimated concentration.

NA - Screening criterion not available

N/A - Not Applicable

(1) USEPA Regional Screening Levels (RSLs) for Tapwater (Target Risk = 10-6; Hazard Quotient = 0.1), November 2013. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/docs/master_sl_table_01run_NOV2013.pdf)

(2) B qualified data were treated as nondetected chemicals because the chemical was detected in the associated blank and the estimated chemical concentration in the sample was not five times greater than the concentration in the associated blank (RAGS A, USEPA, 1989).

(3) Chromium can exist in the environment as chromium (III) and chromium (VI). The analytical results presented in this report are for chromium (total) and do not distinguish between the different valence states. It is assumed that total chromium is composed of chromium (VI) and chromium (III) in a 1 to 6 ratio. The estimated chromium (VI) concentration is calculated by dividing the maximum chromium (total) concentration measured in soil samples by 7. For the site concentration, the maximum chromium (total) concentration is 0.25 µg/L. Therefore, the estimated chromium (VI) concentration is 0.036 µg/L and the chromium (III) concentration is estimated as 0.21 µg/L.

5.4.1.5 MRS 11

Surface Soil

In support of the RI, a total of 28 surface soil samples were collected from MRS 11. Of these, 22 surface soil samples (PR-1011-S-001 through PR-1011-S-020, PR-1011-S-027, and PR-1011-S-028) were collected from DeE2 soils and 6 surface soil samples (PR-1011-S-021 through PR-1011-S-026) were collected from AmC2 soils at MRS 11. All samples were analyzed for explosives and nine metals. The analytical results are presented in Appendix B. Additionally, four soil samples from this area were collected and analyzed in the 2007 SI and those results were considered in this assessment.

The maximum detected concentration of each analyte is compared to PSVs in Table 5-10. Explosives were not detected in any of the soil samples collected at MRS 11. Therefore, explosives were not retained for further consideration in this risk assessment. The maximum detected concentration of eight metals (aluminum, barium, chromium, copper, iron, lead, zinc, and antimony) did not exceed their respective PSVs at MRS 11. However, the maximum detected concentration of mercury (0.4 mg/kg) was detected in sample PR-1011-S-008 at a concentration greater than its PSV (0.1 mg/kg); therefore, mercury is considered a COPC and was retained for further consideration. Additional sampling to delineate mercury was not conducted since ROE was not obtained in the area where step out samples would be placed. Additionally, the one soil sample with mercury detected at a concentration above its PSV was in close proximity of three other samples with mercury detected at concentrations below the PSV, therefore the mercury exceedance is considered a localized occurance.

Surface water and Sediment

Surface water within the MRS is located in an area with no evidence of DoD impact and was sampled and used as a source of background data.

Groundwater

To evaluate the potential risk associated with exposure to groundwater in MRS 11, one groundwater sample (PR-CUL-GW-MRS-11-15) was collected from a newly installed monitoring well at MRS 11 and analyzed for explosives, ammonium picrate, eight MC metals, perchlorate, chloride, and nitrate/nitrite as N. The analytical results are presented in Appendix B.

The maximum detected concentration of each analyte is compared to PSVs (if available) in Table 5-1. Explosives were not detected in any groundwater samples collected at MRS 11. The estimated maximum concentration of chromium (VI) (0.13 µg/L), which is equal to the maximum detected total chromium concentration divided by seven, exceeded its PSV (0.031 µg/L). Chromium will be retained for further evaluation in the risk assessment.

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Table 5-10: Soil Source Evaluation MRS 11

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330									
1,3,5-Trinitrobenzene	mg/kg	0.08	U	DeE2	Yes	0.38	No	No	Not detected at MRS
1,3-Dinitrobenzene	mg/kg	0.08	U	DeE2	Yes	0.61	No	No	Not detected at MRS
2,4,6-Trinitrobenzene	mg/kg	0.08	U	DeE2	Yes	6.4	No	No	Not detected at MRS
2,4-Dinitrotoluene	mg/kg	0.08	U	DeE2	Yes	1.3	No	No	Not detected at MRS
2,6-Dinitrotoluene	mg/kg	0.08	U	DeE2	Yes	0.033	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	mg/kg	0.08	U	DeE2	Yes	10	No	No	Not detected at MRS
2-Nitrotoluene	mg/kg	0.08	U	DeE2	Yes	2.9	No	No	Not detected at MRS
3-Nitrotoluene	mg/kg	0.08	U	DeE2	Yes	0.61	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	mg/kg	0.08	U	DeE2	Yes	3.6	No	No	Not detected at MRS
4-Nitrotoluene	mg/kg	0.08	U	DeE2	Yes	22	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine	mg/kg	0.08	U	DeE2	Yes	5.6	No	No	Not detected at MRS
Nitrobenzene	mg/kg	0.08	U	DeE2	Yes	1.3	No	No	Not detected at MRS
Nitrogylcerin	mg/kg	0.16	U	DeE2	Yes	0.61	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	mg/kg	0.08	U	DeE2	Yes	27	No	No	Not detected at MRS
PETN	mg/kg	0.4	U	DeE2	Yes	100	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	mg/kg	0.08	U	DeE2	Yes	0.99	No	No	Not detected at MRS

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Metals - SW6020A/SW3050B									
Aluminum	mg/kg	37,000		DeE2	Yes	55,000	No	No	Does not exceed PSV
Barium	mg/kg	150		DeE2	Yes	710	No	No	Does not exceed PSV
Chromium	mg/kg	12		DeE2	Yes	26	No	No	Does not exceed PSV
Copper	mg/kg	180		DeE2	Yes	360	No	No	Does not exceed PSV
Lead	mg/kg	21		DeE2	Yes	98	No	No	Does not exceed PSV
Zinc	mg/kg	100		DeE2	Yes	350	No	No	Does not exceed PSV
Antimony	mg/kg	0.8	J	DeE2	Yes	1.2	No	No	Does not exceed PSV
Mercury	mg/kg	0.4		DeE2	Yes	0.1	**Yes**	**Yes**	--

U = undetected at the stated reporting limit.

J = Estimated concentration

2830

2831

2832

Table 5-11: Groundwater Source Evaluation MRS 11

Analyte	Units	Maximum Detected Concentration		Potential MC?	Preliminary Screening Values (PSV) [1]	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330B								
1,3,5-Trinitrobenzene	µg/L	0.30	U	Yes	46	No	No	Not detected at MRS
1,3-Dinitrobenzene	µg/L	0.30	U	Yes	0.15	No	No	Not detected at MRS
2,4,6-Trinitrotoluene (TNT)	µg/L	0.30	U	Yes	0.76	No	No	Not detected at MRS
2,4-Dinitrotoluene	µg/L	0.30	U	Yes	0.20	No	No	Not detected at MRS
2,6-Dinitrotoluene	µg/L	0.30	U	Yes	0.042	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	µg/L	0.30	U	Yes	3.0	No	No	Not detected at MRS
2-Nitrotoluene	µg/L	0.30	U	Yes	0.27	No	No	Not detected at MRS
3-Nitrotoluene	µg/L	0.30	U	Yes	0.13	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	µg/L	0.30	U	Yes	3.0	No	No	Not detected at MRS
4-Nitrotoluene	µg/L	0.30	U	Yes	3.7	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	µg/L	0.30	U	Yes	0.61	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	µg/L	0.30	U	Yes	3.1	No	No	Not detected at MRS
Nitrobenzene	µg/L	0.30	U	Yes	0.12	No	No	Not detected at MRS
Nitroglycerin	µg/L	0.30	U	Yes	0.15	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	µg/L	0.30	U	Yes	78	No	No	Not detected at MRS
Pentaerythritol Tetranitrate (PETN)	µg/L	1.5	U	Yes	3.0	No	No	Not detected at MRS
Ammonium Picrate - SW8321A								
Ammonium picrate	µg/L	0.12	U	Yes	NA	No	No	Not detected at MRS
Total Metals - SW/7470A								
Aluminum	µg/L	1100		Yes	1,600	No	No	Does not exceed PSV
Antimony	µg/L	0.50	U	Yes	0.60	No	No	Not detected at MRS
Barium	µg/L	8.1		Yes	290	No	No	Does not exceed PSV

Analyte	Units	Maximum Detected Concentration	Potential MC?	Preliminary Screening Values (PSV) [1]	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Chromium(total)	µg/L	0.90	Yes	NA	N/A	N/A	N/A
Chromium(III) [2]	µg/L	0.77	Yes	1,600	No	No	Does not exceed PSV
Chromium(VI) [2]	µg/L	0.13	Yes	0.031	Yes	**Yes**	--
Copper	µg/L	27	Yes	62	Yes	No	Does not exceed PSV
Lead	µg/L	1.2	Yes	15	No	No	Does not exceed PSV
Mercury	µg/L	0.15 U	Yes	0.43	No	No	Not detected at MRS
Zinc	µg/L	95	Yes	470	No	No	Does not exceed PSV
Perchlorate - SW6850							
Perchlorate	µg/L	0.32 J	Yes	1.1	No	No	Does not exceed PSV

(NO CODE) - Confirmed identification.

U - Analyte was analyzed for but not detected above the limit of detection (LOD).

J - Analyte detected, estimated concentration.

NA - Screening criterion not available

N/A - Not Applicable

(1) USEPA Regional Screening Levels (RSLs) for Tapwater (Target Risk = 10-6; Hazard Quotient = 0.1), November 2013. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/docs/master_sl_table_01run_NOV2013.pdf)

[2] Chromium can exist in the environment as chromium (III) and chromium (VI). The analytical results presented in this report are for chromium (total) and do not distinguish between the different valence states. It is assumed that total chromium is composed of chromium (VI) and chromium (III) in a 1 to 6 ratio. The estimated chromium (VI) concentration is calculated by dividing the maximum chromium (total) concentration measured in soil samples by 7. For the site concentration, the maximum chromium (total) concentration is 0.90 µg/L. Therefore, the estimated chromium (VI) concentration is 0.13 µg/L and the chromium (III) concentration is estimated as 0.77 µg/L.

5.4.1.6 MRS 13

Surface Soil

In support of the RI, 32 surface soil samples (PR-1013-S-038 through PR-1013-S-069) were collected at MRS 13 and analyzed for explosives and nine metals. Of these, 21 samples were collected in AmC2 soils (PR-1013-038 through PR-1013-054 and PR-1013-058 through PR-1013-061), 8 were collected in DeE2 soils (PR-1013-062 through PR-1013-069), and 3 in Tf soils (PR-1013-055 through PR-1013-057). The analytical results are presented in Appendix B. Additionally, two soil samples from this area were collected and analyzed in the 2007 SI and those results were considered in this assessment.

The maximum detected concentration of each analyte is compared to PSVs in Table 5-12. Explosives were not detected in any of the soil samples collected at MRS 13. Therefore, explosives were not retained for further consideration in this risk assessment. The remaining metals did not exceed their respective PSVs and were also not retained for further evaluation in this risk assessment. Although the maximum detected concentrations of analytes at MRS 13 were in samples collected in AmC2 and DeE2 soils, the maximum detected concentrations of metals in samples collected in Tf soils at MRS 13 also did not exceed their respective PSVs. Therefore, metals were not retained for further consideration in this risk assessment.

Surface Water/Sediment

There is no perennial surface water present on the MRS, therefore the surface water/sediment pathway is incomplete.

Groundwater

No receptors are present, therefore, the groundwater pathway is incomplete.

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Table 5-12: Soil Source Evaluation MRS 13

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330									
1,3,5-Trinitrobenzene	mg/kg	0.08	U	AmC2	Yes	0.38	No	No	Not detected at MRS
1,3-Dinitrobenzene	mg/kg	0.08	U	AmC2	Yes	0.61	No	No	Not detected at MRS
2,4,6-Trinitrobenzene	mg/kg	0.08	U	AmC2	Yes	6.4	No	No	Not detected at MRS
2,4-Dinitrotoluene	mg/kg	0.08	U	AmC2	Yes	1.3	No	No	Not detected at MRS
2,6-Dinitrotoluene	mg/kg	0.08	U	AmC2	Yes	0.033	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	mg/kg	0.08	U	AmC2	Yes	10	No	No	Not detected at MRS
2-Nitrotoluene	mg/kg	0.08	U	AmC2	Yes	2.9	No	No	Not detected at MRS
3-Nitrotoluene	mg/kg	0.08	U	AmC2	Yes	0.61	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	mg/kg	0.08	U	AmC2	Yes	3.6	No	No	Not detected at MRS
4-Nitrotoluene	mg/kg	0.08	U	AmC2	Yes	22	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine	mg/kg	0.08	U	AmC2	Yes	5.6	No	No	Not detected at MRS
Nitrobenzene	mg/kg	0.08	U	AmC2	Yes	1.3	No	No	Not detected at MRS
Nitrogylcerin	mg/kg	0.16	U	AmC2	Yes	0.61	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	mg/kg	0.08	U	AmC2	Yes	27	No	No	Not detected at MRS
PETN	mg/kg	0.4	U	AmC2	Yes	100	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	mg/kg	0.08	U	AmC2	Yes	0.99	No	No	Not detected at MRS

Analyte	Units	Maximum Detected Concentration		Soil Type	Potential MC?	Preliminary Screening Values (PSV) mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Metals - SW6020A/SW3050B									
Aluminum	mg/kg	49,000 (1)		DeE2	Yes	55,000	No	No	Does not exceed PSV
Barium	mg/kg	110 (1)		DeE2	Yes	710	No	No	Does not exceed PSV
Chromium	mg/kg	17 (1)		DeE2	Yes	26	No	No	Does not exceed PSV
Copper	mg/kg	94 (1)		DeE2	Yes	360	No	No	Does not exceed PSV
Lead	mg/kg	8.6 (1)		AmC2	Yes	14	No	No	Does not exceed PSV
Zinc	mg/kg	74 (1)		DeE2	Yes	350	No	No	Does not exceed PSV
Antimony	mg/kg	0.140		AmC2	Yes	0.75	No	No	Does not exceed PSV
Mercury	mg/kg	0.048 (1)		AmC2	Yes	0.1	No	No	Does not exceed PSV

U = undetected at the stated reporting limit.
(1) Maximum detected concentrations from the 2007 SI Report (Parsons, 2007)

5.5 REVISED CONCEPTUAL SITE MODEL

5.5.1 Conceptual Site Model

Conceptual site models (CSMs) evaluate the potential presence or absence of migration/exposure pathways and receptors, based on site-specific conditions. It is necessary to evaluate site-specific conditions and land use to evaluate risks posed to potential receptors under current and future land use scenarios. Exposure pathways for all relevant media are evaluated. The CSMs for the Culebra Island MRSs summarize which potential exposure pathways for receptors are (or may be) complete and which are (and are likely to remain) incomplete. An exposure pathway is not considered to be complete unless all four of the following elements are present (USEPA, 1989):

- A source of contamination
- An environmental transport and/or exposure medium
- A point of exposure at which the contaminant can interact with a receptor
- A receptor and a likely route of exposure at the exposure point.

If any single factor listed above is not present, the pathway would be incomplete. An incomplete pathway indicates that there are no means by which a receptor (human or ecological) can come in contact with either MC or MEC. Therefore, no risk would be expected from that exposure pathway.

As part of the TPP process, the TPP Team developed a CSM that included each of the eight investigation areas based on information available at the time (Appendix Q of the WP). The CSM developed in support of the TPP process is presented in Chapter 3 (Figures 3-1 through 3-6). A CSM is a dynamic document that is to be evaluated and revised each time new information is received. As an SI was completed for this site, the initial CSMs for this RI were based on the SI findings (Parsons, 2007). Based on the results of the contaminant characterizations conducted for each MRS, the initial CSM described in Subsection 3.1 was reviewed and updated to reflect newly established MSRs, potentially complete pathways, and any MC detected above screening criteria (COPCs). The following figures present the revised CSM for the Culebra Island MRSs:

- Figure 5-7: Revised CSM for MRS 06 North
- Figure 5-8: Revised CSM for MRS 06 South
- Figure 5-9: Revised CSM for MRS 08
- Figure 5-10: Revised CSM for MRS 09
- Figure 5-11: Revised CSM for MRS 10
- Figure 5-12: Revised CSM for MRS 11 North
- Figure 5-13: Revised CSM for MRS 11 South
- Figure 5-14: Revised CSM for MRS 13

5.5.2 Land Use

Current and future land use for each Culebra Island MRS is described in Subsection 2.2.11.

5.5.3 MEC Exposure Pathways

The following paragraphs evaluate the potential exposure pathways for MEC/MD at each MRS. CSMs depicting these pathways, presented for MRSs 06, 08, 009, 10, 11, and 13, are shown in Figures 5-7 through 5-14, respectively.

5.5.3.1 MRS 06 Artillery Firing Area

Four subsurface MD items were found in Grids 06-03 and 06-17. Two artillery primers were recovered at 2 to 3 inches bgs. Two pieces of MD (fragments) were recovered at a depth of 2 inches bgs. These two MD items are considered isolated pieces of munitions fragments that may be from munitions some distance away, so their presence does not necessarily indicate a significant hazard. Based on the anticipated continued development of this area, the unlimited access, and MD in the subsurface, the MEC exposure pathway is considered complete for MRS 06.

5.5.3.2 MRS 08 Cayo Norte Impact Area

Thirteen MD items were recovered in six grids within MRS 08 (Grids 08-02, 08-03, 08-06, 08-07, 08-08, and 08-09). All 13 MD items were identified to be fragmentation from 75 mm projectiles and were recovered 0 to 3 inches bgs. Based on the anticipated continued development of this area, and the unlimited access (by boat), the surface and subsurface MEC exposure pathway is considered complete for MRS 08.

5.5.3.3 MRS 09 Soldado Point Mortar And Bombing Area

Seven MD items were recovered 0 to 3 inches bgs in three grids (09-04, 09-07, and 09-13) within MRS 09. Two MEC items (Mk 25 Marine Marker Flares) were recovered along the surface along the DGM transects located close to the coves. Based on the anticipated continued recreational of beach areas, and the unlimited access, the surface and subsurface MEC exposure pathway is considered complete for MRS 09.

5.5.3.4 MRS 10 Defensive Firing Area No. 1

No MEC or MD items were recovered within the upland grids or along the beach areas of MRS 10. Based on the absence of MEC on the surface and subsurface, the MEC exposure pathway is considered incomplete for MRS 10.

5.5.3.5 MRS 11 Defensive Firing Area No. 2 North

Fifteen MD items were recovered 0 to 4 inches bgs in the upland grids (11-13, 11-14, 11-15, 11-16, and 11-17) and two MD items were recovered 0 to 3 inches bgs from beach transects (11M-08 and 11M-11). Based on the anticipated continued development and recreational use of this area, and the unlimited access, the surface and subsurface MEC exposure pathway is considered complete for MRS 11 North.

5.5.3.6 MRS 11 Defensive Firing Area No. 2 South

As previously mentioned, no MEC or MD items were recovered in the southern portion of MRS 11. Based on the anticipated continued development and recreational use of this area, and the

unlimited access, the surface and subsurface exposure pathway is considered complete; however, the likelihood for receptors to encounter MEC in MRS 11 South is considered to be very low.

5.5.3.7 MRS 13 Cayo Luis Pena Impact Areas

Ten MD items and two expended small arms ammunition items were recovered 0 to 18 inches bgs within MRS 13 beach areas. Additionally, during surface reconnaissance from a 2009 post award site visit on unestablished trails, MD from 105mm projectiles (1-HE, 1-illumination, 4-unidentified), 5-inch projectiles (31), 3-inch projectiles (3), flares (8), fuzes, and other MD pieces was observed at 112 locations. Based on the anticipated continued recreational use of this area, and the unlimited access (by boat), the surface and subsurface MEC exposure pathway is considered complete for MRS 13.

5.5.4 MC Exposure Pathways

The following sections evaluate the potential exposure pathways for MC at the Culebra Island MRSs. The CSMs depicting these pathways are presented in Figures 5-7 through 5-14.

5.5.4.1 Potential Receptors

5.5.4.1.1 MRS 06 (North and South)

The majority of MRS 06 is comprised of private residences; other areas contain undeveloped tracts that are steep with heavy vegetation. Potential receptors include residents, construction workers, onsite workers, recreational users, and trespassers.

Sensitive ecological receptors are identified in Chapter 2, and include (with habitat) the leatherback turtle (beaches), hawksbill turtle (beaches), Virgin Islands tree boa (forest with continuous canopy and abundant anoles), Grant's leptocereus (non-forest and forest).

5.5.4.1.2 MRS 08

MRS 08 is a privately owned island. Potential receptors include residents, construction workers, onsite workers, recreational users, and trespassers.

Sensitive ecological receptors are identified in Chapter 2, and include (with habitat) the leatherback turtle (beaches), hawksbill turtle (beaches), Virgin Islands tree boa (forest with continuous canopy and abundant anoles), Culebra giant anole (mature forest), and Culebrita water willow (coastal scrub shrub).

5.5.4.1.3 MRS 09

The majority of MRS 09 is managed by the PR DNER. Other areas contain small residences. Potential current and future receptors include residents, construction workers, onsite workers, recreational users, and trespassers.

Sensitive ecological receptors are identified in Chapter 2, and include (with habitat) the hawksbill turtle (beaches), and Grant's leptocereus (non-forest and forest).

5.5.4.1.4 MRS 10

The majority of MRS 10 is comprised of private residences and commercial areas. Other areas contain undeveloped tracts that are steep with heavy vegetation. Potential current and future receptors include residents, construction workers, onsite workers, recreational users, and trespassers.

Sensitive ecological receptors include species identified in Chapter 2, and include (with habitat) the hawksbill turtle (beaches), Virgin Islands tree boa (forest with continuous canopy and abundant anoles), Culebra giant anole (mature forest), Grant's leptocereus (non-forest and forest) and Wheeler's peperomia (forest).

5.5.4.1.5 MRS 11 (North and South)

The majority of MRS 11 is comprised of private residences and industrial areas. Other areas contain undeveloped tracts that are steep with heavy vegetation. Potential current and future receptors include residents, construction workers, onsite workers, recreational users, and trespassers.

Sensitive ecological receptors include species identified in Chapter 2, and include (with habitat) the hawksbill turtle (beaches), Virgin Islands tree boa (forest with continuous canopy and abundant anoles), Culebra giant anole (mature forest), Grant's leptocereus (non-forest and forest) and Wheeler's peperomia (forest).

5.5.4.1.6 MRS 13

MRS 13 is an island that is managed by USFWS and is undeveloped with steep terrain and heavy vegetation. Potential current and future receptors include onsite workers and recreational users.

Sensitive ecological receptors are identified in Chapter 2, and include (with habitat) the leatherback turtle (beaches), hawksbill turtle (beaches), Virgin Islands tree boa (forest with continuous canopy and abundant anoles), Culebra giant anole (mature forest), Culebrita water willow (coastal scrub shrub), Grant's leptocereus (non-forest and forest), and Wheeler's peperomia (forest).

5.5.4.2 Potential Exposure Pathways for Human and Ecological Receptors

Potential exposure pathways to both human and ecological receptors are presented below and summarized on the CSMs presented in Figures 5-7 through 5-14.

5.5.4.2.1 Surface and Sub-Surface Soil

Potential exposure to MC contamination in soil could occur through the following pathways:

- Incidental ingestion of soil
- Dermal contact with soil
- Inhalation of re-suspended particulate matter from soil.

All potential human receptors previously mentioned for each Culebra Island MRS could interact with the pathways mentioned above. Potential ecological receptors exist in all Culebra Island MRSs, which could be potentially affected through the ingestion and dermal contact pathways.

Very little sub-surface soil is present on the island and none was encountered in the MEC investigation, beyond the highly dynamic beach areas. Therefore, the sub-surface pathway was not evaluated.

5.5.4.2.2 Surface Water and Sediment

Due to runoff from the surrounding areas, surface water and sediment are present within some of the Culebra Island MRSs. Potential exposure to MC contamination in surface water and sediment could occur through the following pathways:

- Incidental ingestion of surface water or sediment
- Dermal contact with surface water or sediment.

All potential human receptors previously mentioned for each Culebra Island MRS could interact with the pathways mentioned above. Potential ecological receptors exist in all Culebra Island MRSs, which could be potentially affected through the ingestion and dermal contact pathways.

5.5.4.3 Groundwater

While releases of MC directly to groundwater is not expected due to the depth of groundwater at the site compared to the penetration depth of ordnance used at the site, there is a potential for MC to migrate from soil to groundwater. Despite the fact that groundwater use is not expected or feasible at many areas on site, due to Puerto Rico's Water Quality Standard Regulation, which classifies all groundwater as potable, future water wells could, in theory, be permitted and installed to supply residents of Culebra Island. While unlikely, potential exposure to MC contamination in groundwater could occur through the following pathways:

- Incidental ingestion of groundwater
- Ingestion of groundwater as drinking water
- Dermal exposure to groundwater

Potential receptors of these pathways include:

- Current and future residents
- Current and future commercial and industrial workers
- Current and future excavation and construction workers

Currently, no complete pathway exists for ecological receptors with regard to groundwater.

5.5.4.4 Incomplete Pathways

Inhalation of volatile compounds by on-site receptors was evaluated and considered incomplete for human and ecological receptors at the Culebra Island MRSs.

Inhalation of VOCs from soil or groundwater, or vapor intrusion of Volatile Organic Compounds (VOCs) from groundwater into buildings are incomplete exposure pathways, as no volatile compounds are MC of the munitions discovered during the RI.

The groundwater survey conducted in 2013 did not find any evidence that groundwater was in use as a drinking water source. Previous studies have noted that the five existing PRASA wells can not meet island water demand, and there is no reason to suspect the current supply of drinking water piped in from the Puerto Rico mainland will change. A permit is required before installation of any new wells. For MRS 08, the absence of permanent residences, the small acreage of the island which would be significantly impacted by saltwater intrusion and the volcanic nature of the island with groundwater storage in fractures, coupled with logistical challenges for drilling equipment, indicate future groundwater use is unlikely. For MRS 13 no residences are present onsite and will not be present in the future.

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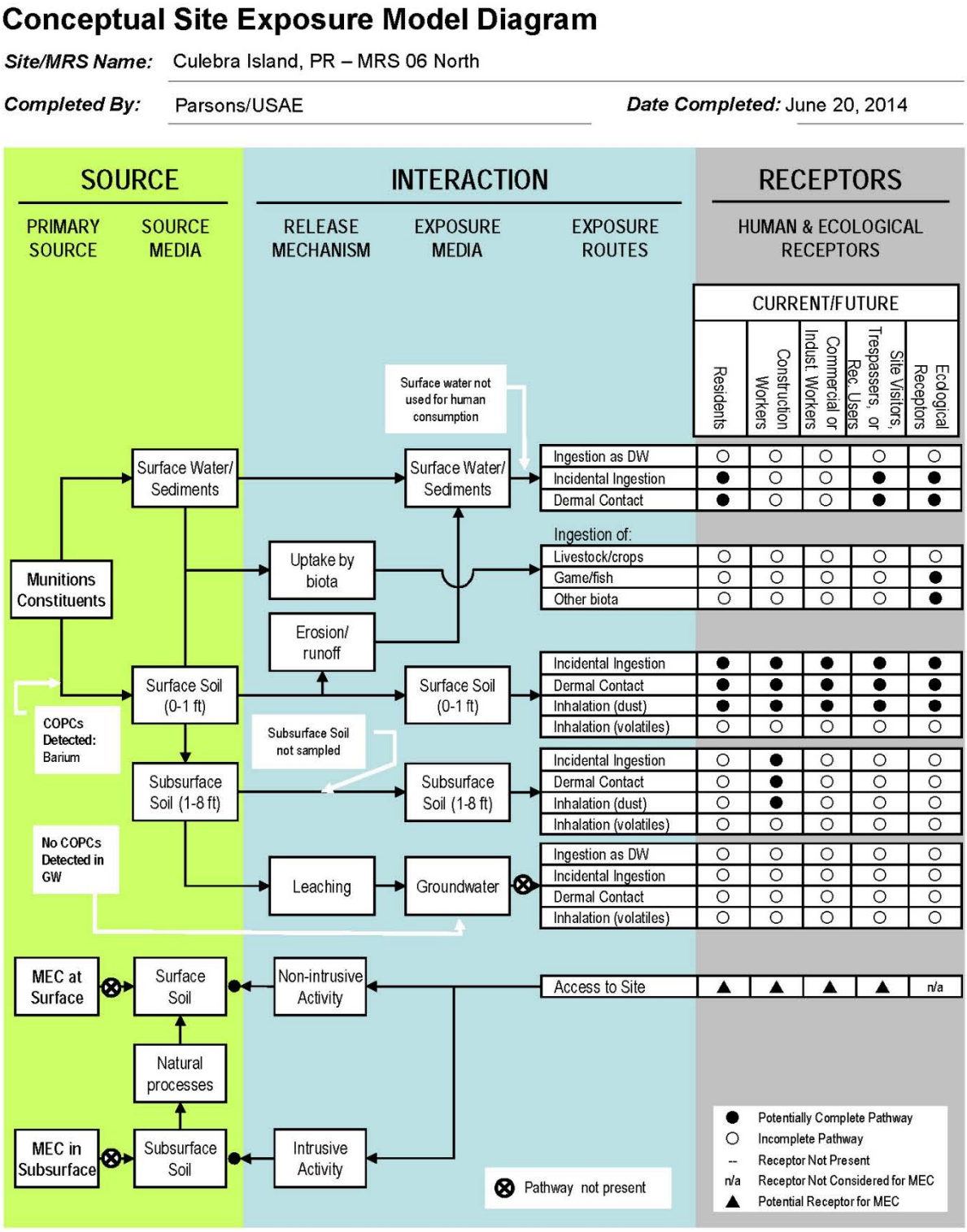

Figure 5-7: Revised CSM for MRS 06 North

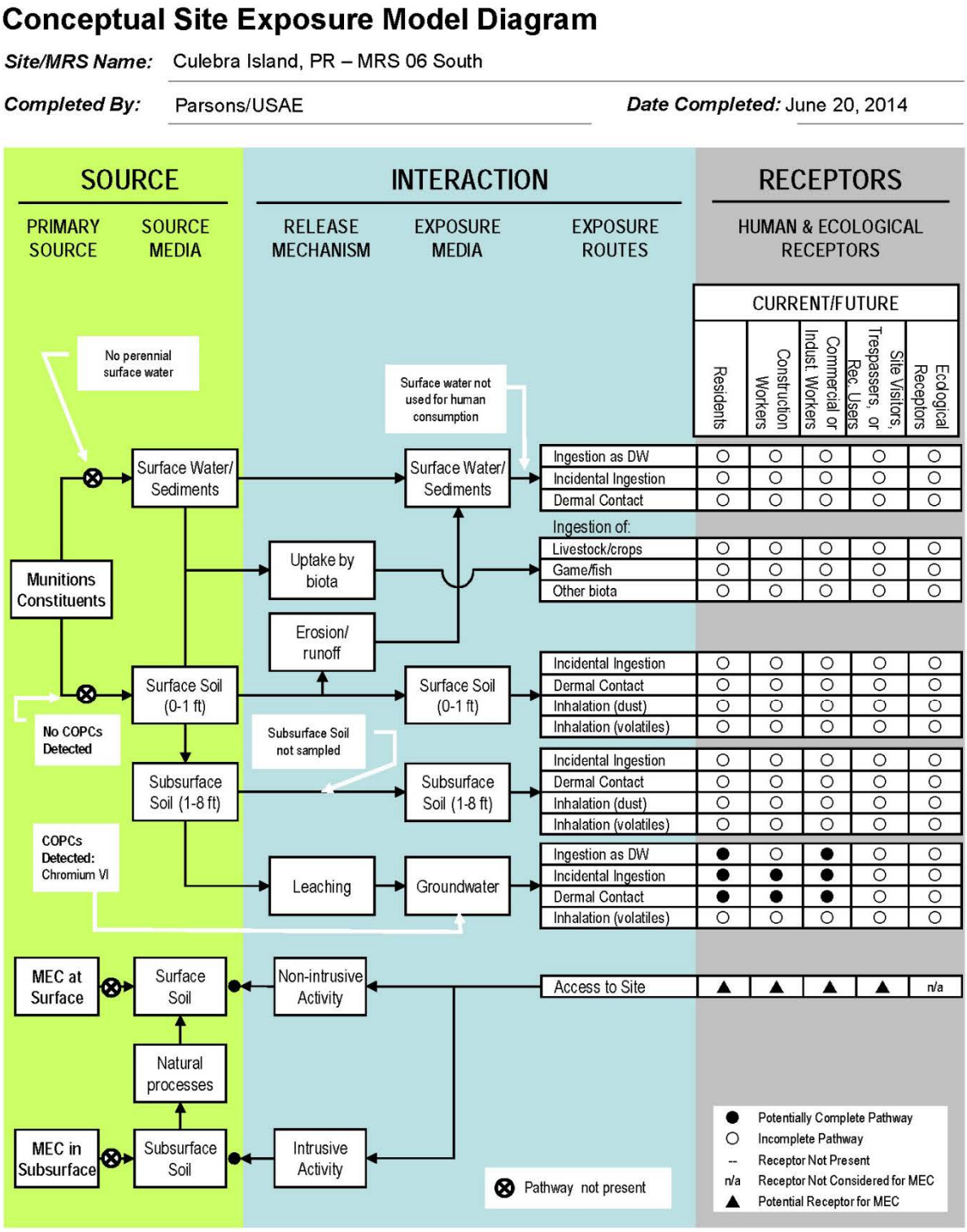

Figure 5-8: Revised CSM for MRS 06 South

Conceptual Site Exposure Model Diagram

Site/MRS Name: Culebra Island, PR – MRS 08

Completed By: Parsons/USAE ***Date Completed:*** June 20, 2014

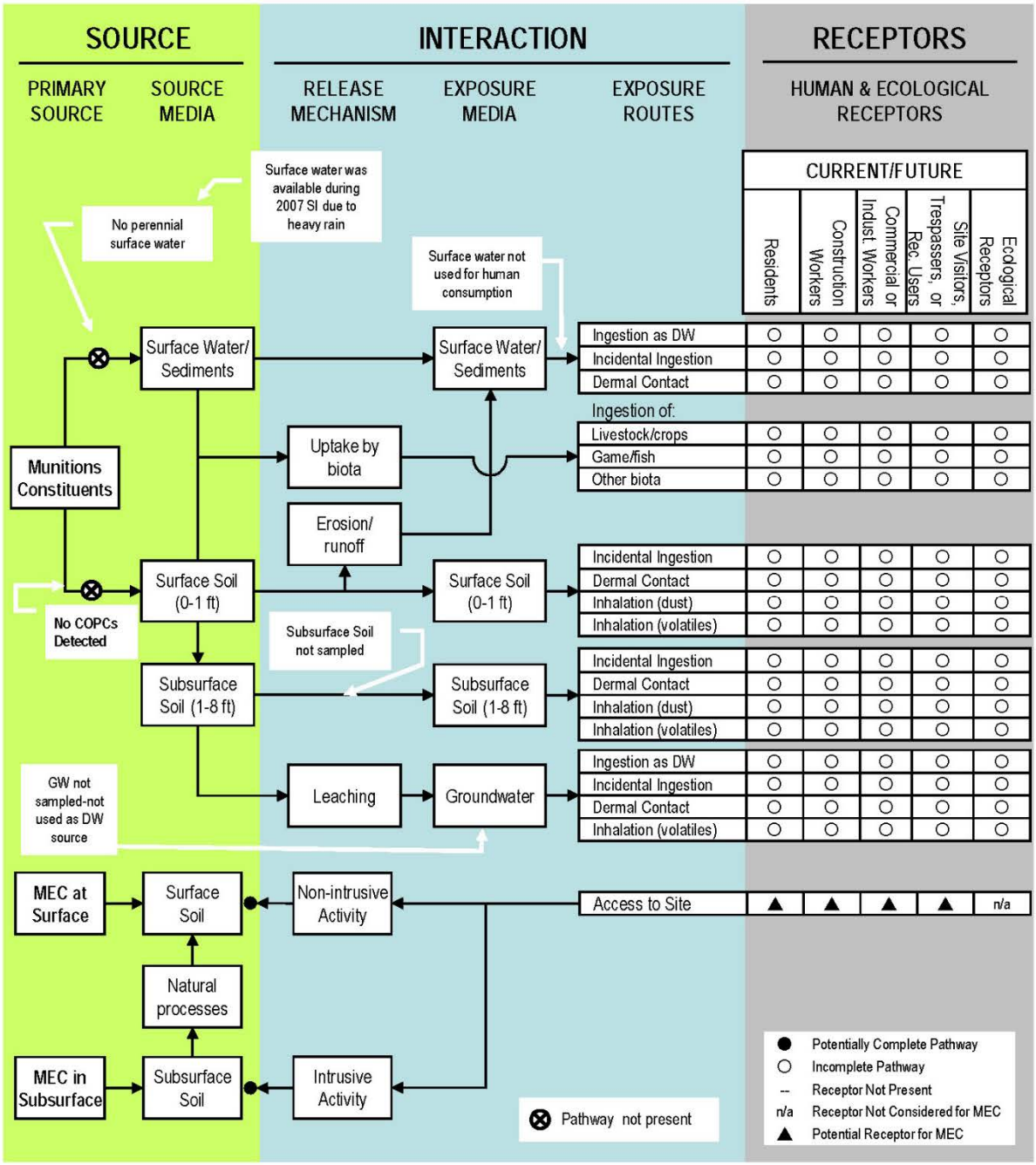

Figure 5-9: Revised CSM for MRS 08

Conceptual Site Exposure Model Diagram

Site/MRS Name: Culebra Island, PR – MRS 09

Completed By: Parsons/USAE ***Date Completed:*** June 20, 2014

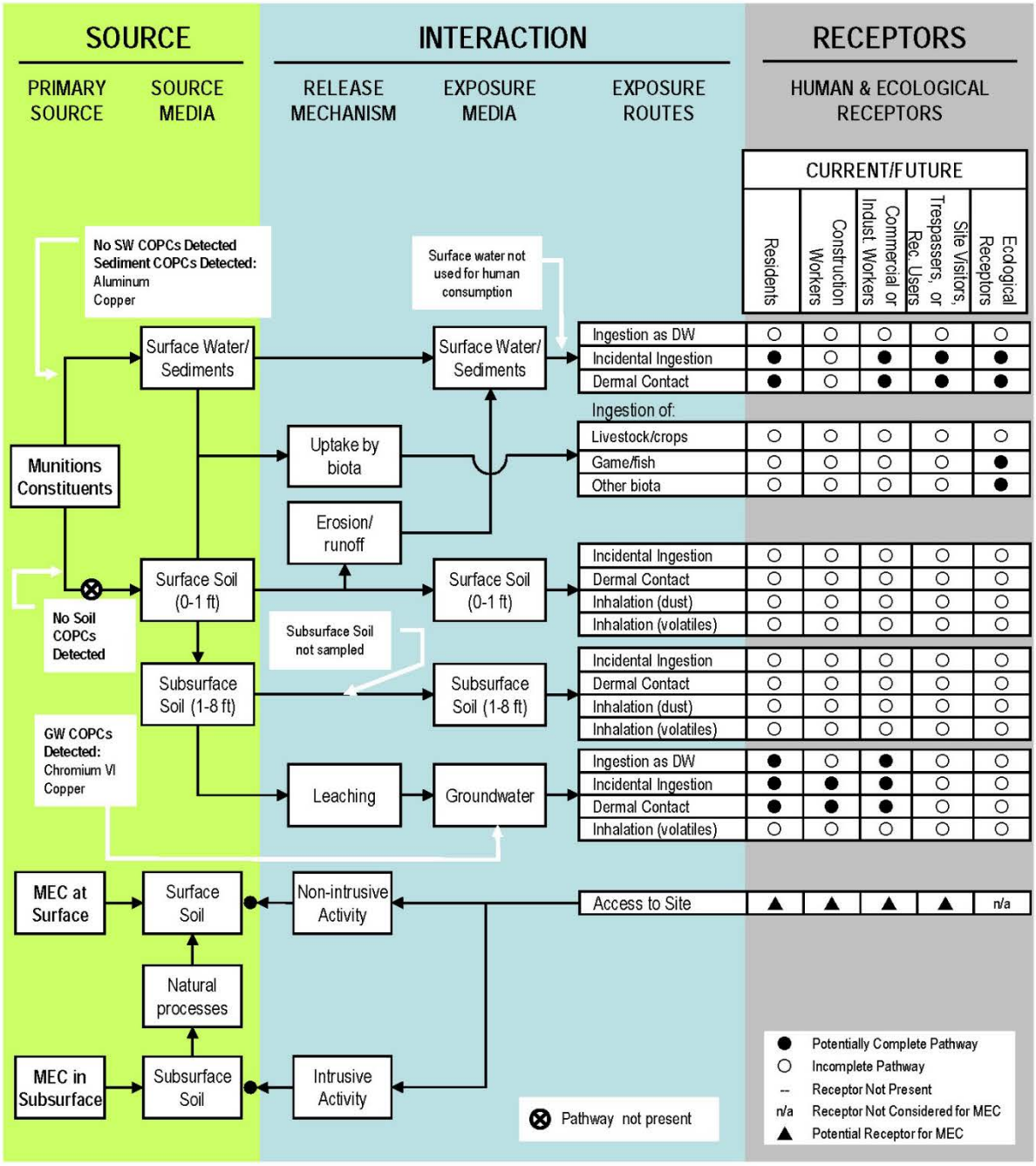

Figure 5-10: Revised CSM for MRS 09

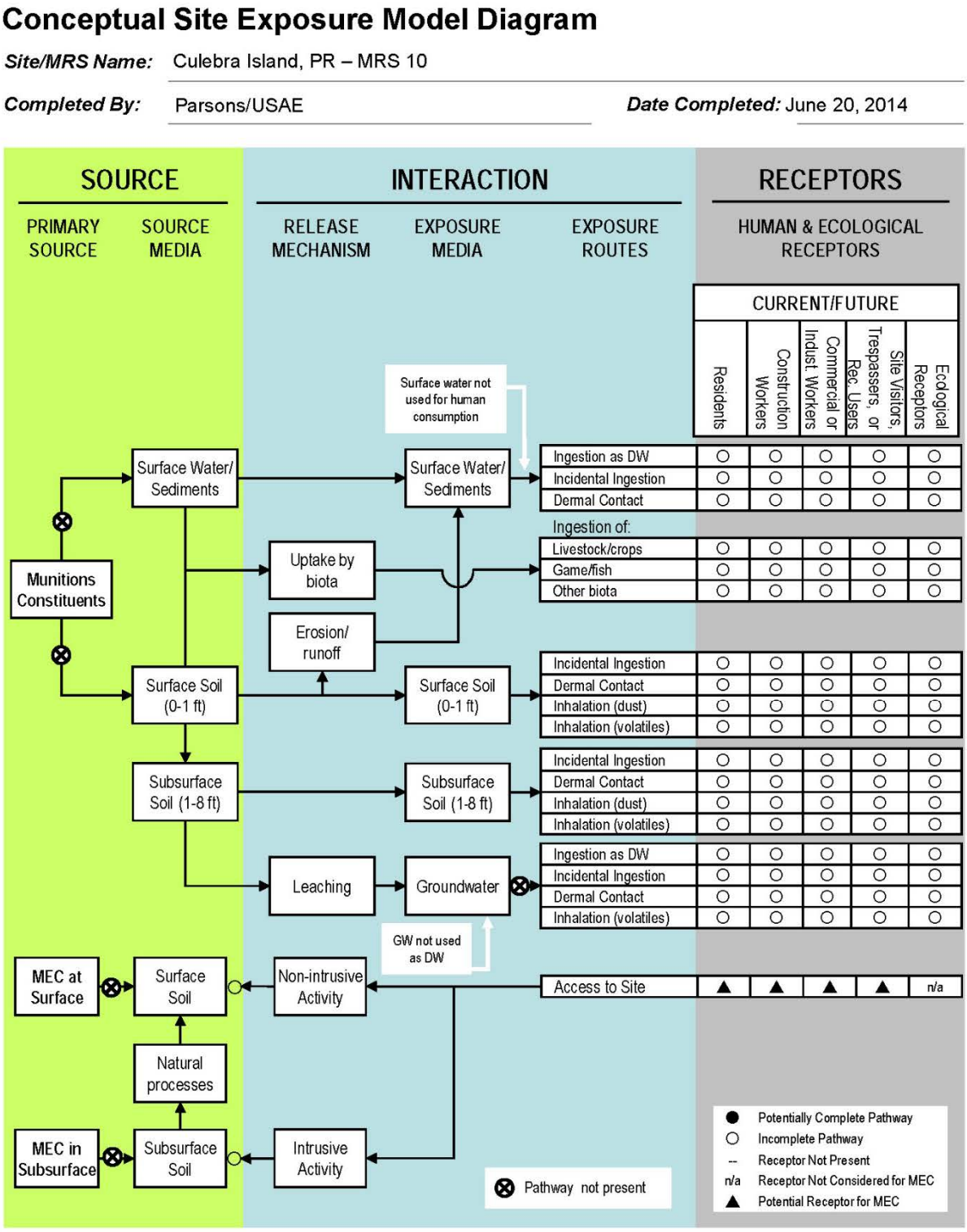

Figure 5-11: Revised CSM for MRS 10

Conceptual Site Exposure Model Diagram

Site/MRS Name: Culebra Island, PR – MRS 11 North

Completed By: PARSONS/USAE ***Date Completed:*** June 20, 2014

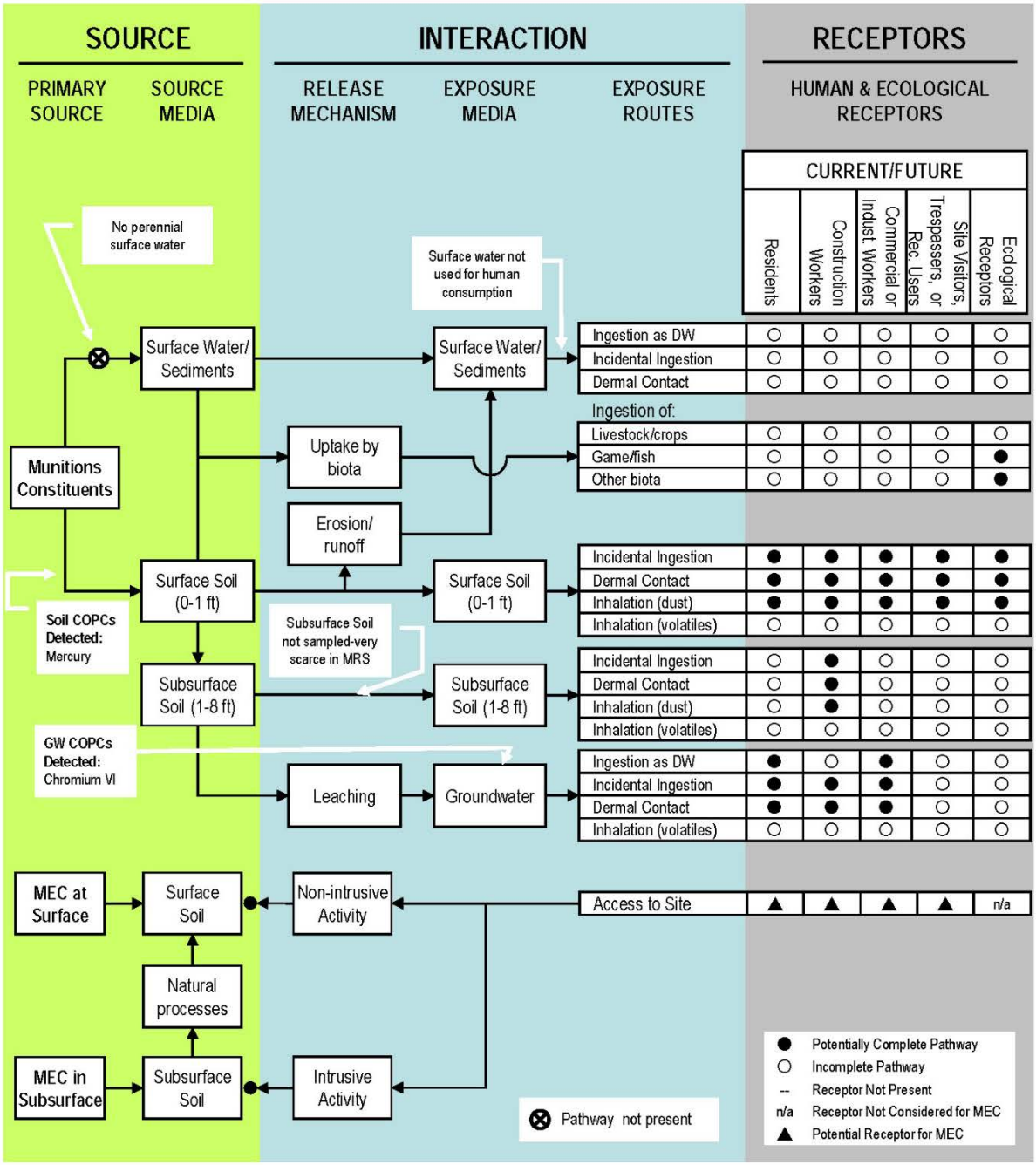

Figure 5-12: Revised CSM for MRS 11 North

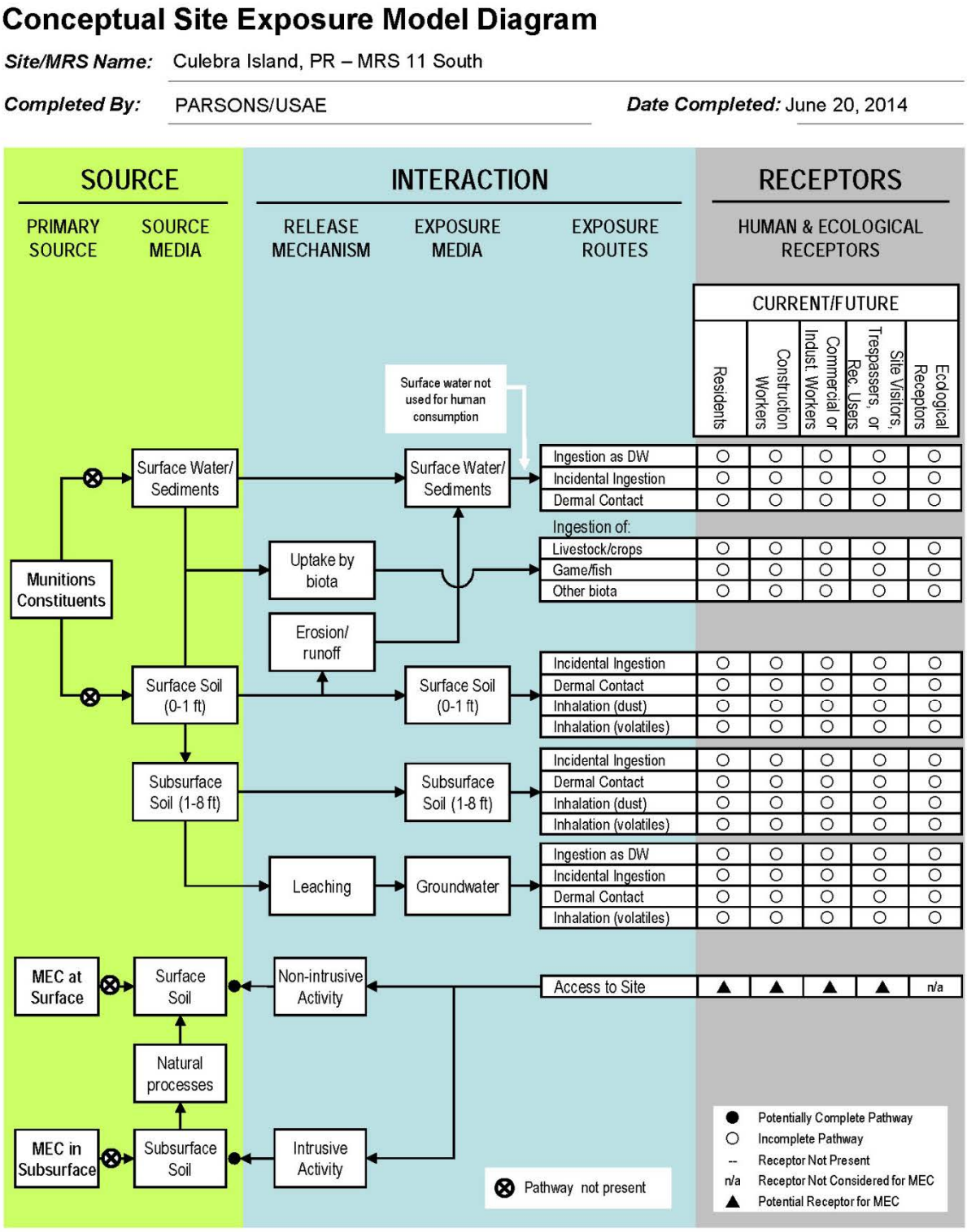

Figure 5-13: Revised CSM for MRS 11 South

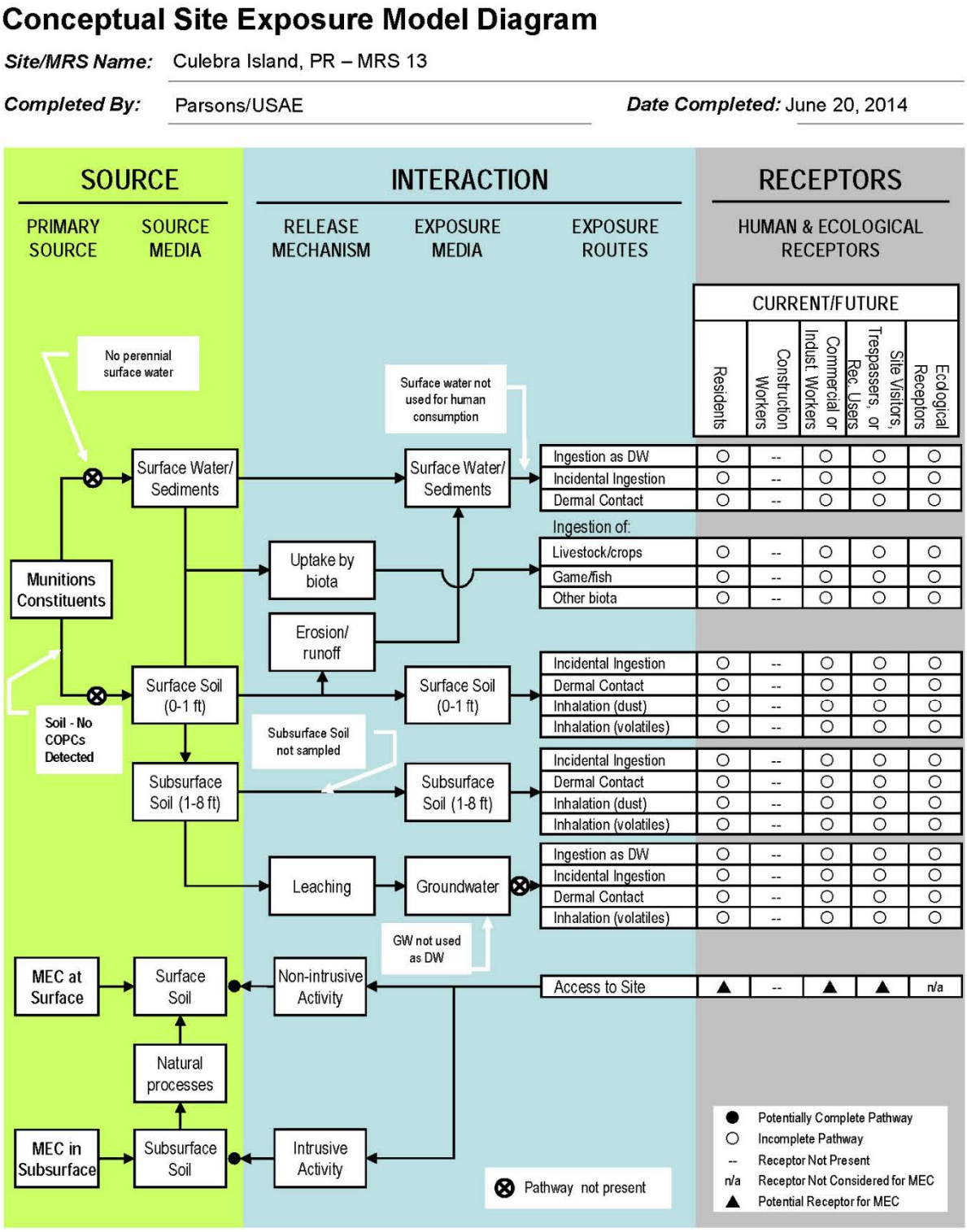

Figure 5-14: Revised CSM for MRS 13

CHAPTER 6. CONTAMINANT FATE AND TRANSPORT FOR MEC AND MC

6.1 FATE AND TRANSPORT OF MEC

The primary MEC transport mechanisms identified at the Culebra Island MRSs include soil disturbance and erosion. Other human activities such as beach replenishment and relocation of MEC/MD items are possible transport mechanisms. Based on the current and anticipated future use of the MRS, intrusive activities and shoreline erosion (beach areas) are the most likely pathways for exposures to MEC within the Culebra Island MRSs.

6.2 FATE AND TRANSPORT OF MC

Many different environmental processes act upon MC which may influence or alter its availability to interact with receptors. These processes are fully reliant on the media in which the potential source (MEC or MD) exists and the exposure of MC to the processes. These environmental processes work through the different media: air, soil, surface water, groundwater, or biota. The following list contains short descriptions of these processes as described in Hewitt, et al. (2003):

- **Advection** – the passive movement of a solute with flowing water.
- **Dispersion** – the general term applied to the observed spreading of a solute plume and generally attributed to hydrodynamic dispersion and molecular diffusion.
- **Adsorption/desorption** – the process by which dissolved, chemical species accumulate (adsorption) at an interface or are released from the interface (desorption) into solution.
- **Diffusion** – the migration of solute molecules from regions of higher concentration to regions of lower concentration.
- **Biotic transformation** – the modification of a chemical substance in the environment by a biological mechanism.
- **Oxidation/reduction** – reactions in which electron(s) are transferred between reactants.
- **Covalent binding** – the formation of chemical bonds with specific functional groups in soil organic solids
- **Polymerization** – the process by which the molecules of a discrete compound combine to form larger molecules with a molecular weight greater than that of the original compound, resulting in a molecule with repeated structural units.
- **Photolysis** – the chemical alteration of a compound due to the direct or indirect effects of light energy.
- **Infiltration** – the process by which water enters the soil at the ground surface and moves into deeper horizons.
- **Evapotranspiration** – the collective processes of evaporation of water from water bodies, soil and plant surfaces, and the transport of water through plants to the atmosphere.
- **Plant root uptake** – the transport of chemicals into plants through the roots.

- **Sedimentation** – The removal from the water column of suspended particles by gravitational settling.

6.3 CONTAMINANT PERSISTENCE FOR MUNITIONS CONSTITUENTS

The MC discussed in this section are only those that upon completion of the screening level risk assessment warranted further consideration and consequently, have the potential to present an unacceptable risk to human health or the environment. For MRSs 06, 09, and 11, the only MC in soil that meet this criterion are aluminum, barium, copper, and mercury. For MRS 06S, 09, and 11N the MC in groundwater that met this criterion are copper and chromium.

6.3.1 Metals

Metals, although naturally occurring, can be a concern when casings, projectiles, fuzes, propellants, or other components of military munitions corrode or leach into the environment.

Chemical and physical properties affect the mobility of metals in soil and groundwater. A variety of reactions can occur that influence the speciation and transport of metal contaminants in soil and groundwater environments including acid/base, precipitation/dissolution, oxidation/reduction, sorption or ion exchange. The rate and extent of these reactions depends on factors such as pH, complexation with other dissolved constituents, sorption and ion exchange capacity of the geological materials, and organic matter content. Under relatively acidic conditions (pH ranges between 4.0 and 8.5), metal cations are mobile while anions tend to transform to oxide minerals. At high pH levels, cations adsorb into mineral surfaces and metal anions are mobilized. Other changes in soil environment conditions over time, such as the degradation of the organic waste matrix, oxidation-reduction potential, or soil solution composition, due to natural weathering processes, also may enhance the mobility of metals. The immobility of metals is primarily caused by reactions that cause metals to precipitate or chemical reactions that keep metals in a solid phase (Evanko and Dzombak, 1997).

To determine the potential existence of these MC within the sites investigated, environmental samples (soil, surface water, sediment) were collected and analyzed during the SI and RI field efforts.

6.3.2 Aluminum

Aluminum is an abundant natural element and the most common metal in the earth's crust. The aluminum content of soils is strongly correlated with its clay content and soil pH. Aluminum is released to the environment both by natural processes of soil weathering and anthropogenic sources such as mining and agriculture. Aluminum is not found as a free metal because of its reactivity, but occurs in the form of silicates, oxides, hydroxides, and as complexes with organic matter (HDSB 2011). Aluminum and its compounds appear to be poorly absorbed in humans. The mechanism of gastrointestinal absorption of aluminum has not yet been fully elucidated. The highest levels of aluminum may be found in the lungs, where it may be present as inhaled insoluble particles. The urine is the most important route of aluminum excretion.

At pH values above 5.0, aluminum ions become strongly bound as polymeric hydroxy cations at the surface of the silicate minerals. Exchangeable aluminum, as well as the aluminum concentration in the soil solution, is negligible. In the pH range 5 to 4.2, aluminum ions occupy increasing fractions of exchangeable cations. Natural water systems acquire aluminum through

weathering reactions, which involve the interaction of water and atmosphere with the earth's crust and subsequent leaching of aluminum compounds into water. Aluminum exists as trivalent aluminum in aqueous solution (HSDB 2011).

Aluminum is used in munitions in incendiaries, composition explosives, propellants, pyrotechnics (powdered Al), and in rocket casings (alloys).

6.3.3 Barium

Barium occurs naturally in the earth's crust and is present largely as compounds with another element. Barium sulfate (barite) and barium carbonate (witherite) are two very insoluble naturally occurring minerals, which are commonly found as underground ore deposits. Barium and its compounds are also found naturally in food and drinking water. The types of barium compounds found in drinking water vary, as some compounds are not easily soluble with water. Those compounds which may be found in water are usually of the type that are not commonly found in nature and are most likely present due to localized anthropogenic sources. Barium's persistence is determined by the form (compound) in which it is released. Non-soluble forms of barium (e.g., barium sulfate) have the potential of persisting in the environment for a significant length of time, and those compounds which have greater water solubility tend to have a shorter life, but can eventually combine with sulfate or carbonate to form a more persistent compound. The sulfate and carbonate compounds have a higher partition to organic (soil) matter (ATSDR, 2009).

Barium has few industrial applications. Soluble barium compounds are poisonous due to the release of the soluble barium ion and have been used in rodenticides. Barium sulfate, because of its high density, is used in the petroleum industry as a weighting agent in drilling mud and it is also used as filler in rubber. Other barium compounds have niche applications including barium oxide, which is used as a coating for the electrodes in fluorescent lamps; barium carbonate, which is used in glassmaking; and barium nitrate, which is used to create green colors in fireworks.

Barium compounds (barium nitrate, barium stearate, and barium chromate) are used in propellant, energetic, and pyrotechnics (PEP) of military munitions (GAIA Corporation, 2002). Other non-munitions sources of barium at Culebra could be attributed to the natural geology of the site.

6.3.4 Chromium

Anthropogenic sources include combustion of fossil fuels, pigments, metal alloys, glass coloring, steel and welding materials, textile industry, photography, fuel additives, magnetic tapes, industrial water treatment, paper mills, and fertilizers. Additionally, chromium is found naturally in rocks, ores, minerals, volcanic dust, and gases from the earth's crust. Under normal conditions, chromium is dispersed throughout the environment primarily as a result of anthropogenic activity. The concentration of chromium varies widely in soil. For example, in a study within the conterminous United States, chromium concentrations in soil ranged from 70 parts per million (ppm) to 700 ppm (USGS, 1984).

6.2.3.3.2 Chromium occurs in two major forms; trivalent or chromium(III) and hexavalent or chromium (VI). Chromium (III) is considered an essential nutrient for humans. Hexavalent

chromium is more toxic. Chromium is primarily present in soil as insoluble oxide (Agency for Toxic Substances and Disease Registry [ATSDR], 2008).

6.2.3.3.3 Chromium (VI) is eventually reduced to chromium (III) by the organic material present in surface water and generally forms stable complexes with organic matter. Therefore, based on the potential source of chromium (i.e., munitions) and absence of surface water bodies, chromium is expected to be present in soil at Culebra Island as chromium (III). To be conservative, however, hexavalent and trivalent chromium were both further evaluated in the risk assessment.

Chromium used in munitions is a component of armor piercing bullets, pyrotechnics, and present in some steel alloys of casings.

6.3.5 Copper

Copper occurs naturally in rock, soil, water, and sediment. Copper occurs in numerous minerals such as cuprite, tenorite, malachite, and azurite. It is an essential element for all known living organisms including humans and other animals at low levels of intake, with dietary ingestion providing the primary source of the necessary copper (HSDB, 2001). Copper is primarily used in the manufacture of wire, sheet metal, pipe, in agriculture to treat plant diseases, for water treatment, and as preservatives for wood, leather, and fabrics.

When copper is released into soil, it can become strongly attached to the organic material and other components (e.g., clay, sand, etc.) in the top layers of soil and may not move very far when it is released. Hydrolysis and precipitation reactions dominate the chemistry of copper compounds in most natural aqueous systems. Soluble copper compounds sorb strongly to suspended particles. The presence of complexing organic ligands can stabilize dissolved copper compounds in fresh water systems and prevent copper sorption onto solids. Most insoluble and soluble copper compounds are associated with solids, have low mobility in soil, and are not expected to volatilize from water or moist soil surfaces. There is no evidence that supports the existence of biotransformation processes for copper compounds which would have a significant bearing on the fate of copper in aquatic environments.

Copper is used extensively in military munitions in alloys of casings, solid munition components, paints, and coatings. Copper is also a constituent of the jet perforators used for the demolition of munitions.

6.3.6 Mercury

Mercury can be emitted to the atmosphere as a gas (elemental and oxidized chemical forms) or a particulate (oxidized forms), and subsequently return to the earth in the form of dry or wet deposition. The residence time of mercury emissions in the atmosphere is influenced by state (e.g., whether it is in gas or particulate form) and solubility, with vapor forms of elemental mercury having the longest residence times (NESCAUM et al., 1998). Over 95% of the atmospheric mercury is in the elemental form as mercury vapor (RTI, 1999). Elemental mercury vapor is not thought to be susceptible to any major direct deposition processes due to its relatively high vapor pressure and low water solubility. However, ozone promotes the oxidation of elemental mercury to the more-soluble divalent form, which is then subject to dissolution into precipitation and subsequent wet deposition or binding to particles which are then subject to dry

and wet deposition (USEPA, 1997). Methylmercury is also present in wet deposition, although at much lower concentrations than divalent mercury. Atmospheric deposition as a source of methylmercury has been found to decrease with distance from areas of ocean upwelling and industrial sources (South Florida Water Management District, 1999).

If deposited in a soil environment, divalent forms of mercury complex with organic matter and mineral materials to form inorganic compounds [e.g., $HgCl_2$ and $Hg(OH)_2$] and complexes of inorganic divalent mercury and organic compounds. While inorganic mercury compounds are quite soluble, they form complexes with soil organic matter and, to a lesser extent, mineral colloids. These complexes greatly limit the mobility of the inorganic mercury compounds. As a result, much of the soil mercury is bound to organic materials and is then subject to removal by erosion. To a minor extent, the divalent mercury can be absorbed onto dissolvable organic ligands and other forms of dissolved organic carbon and thereby be removed via runoff. Leaching is a relatively insignificant transport process. Microbial processes acting on divalent mercury compounds can cause small amounts of methylmercury to form in surface soil. Methylmercury typically accounts for only 1 to 3% of the total mercury in surface soils (the percentage can exceed 3% in soils with high organic content under slightly acidic conditions). The presence of humic substances and light can also reduce divalent mercury in soil to elemental mercury, which is then subject to volatilization (USEPA, 1997).

Mercury is used in munitions as a primary explosive in the form of mercury fulminate.

6.4 SUMMARY

As stated in Chapter 5, four metals were detected in soil and two metals in groundwater at concentrations above screening levels and are associated with munitions that were used during military operations at Culebra. A representation of environmental conditions for the Culebra Island Site is discussed below.

The six MRSs that were evaluated at part of this RI/FS Risk Assessment are at noncontiguous locations within the Culebra Island Site; however, these sites contain similar types of soils. The soils that make up these sites are DeE2, DrF, Rs, and AmC2. These soils tend to consist of silts and clays, which are shallow, and become more organic near the beaches.

Average rainfall in Culebra is approximately 40 inches, with the heaviest rain in September, October, and November. The months of August through November are considered the wet season, and the driest months are January through April.

Constituents released as part of the destruction of UXO by detonation present the possibility of a future contaminant release into the environment, which could potentially affect humans or ecological receptors coming into contact with the contaminant. Risks associated with these MC and the pathways present are further evaluated in Chapter 7.

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CHAPTER 7. BASELINE RISK ASSESSMENT FOR MC AND HAZARD ASSESSMENT FOR MEC

7.1 INTRODUCTION

The need for remedial actions to reduce risks to human health or the environment must be demonstrated through the use of either quantitative or qualitative risk assessments. A baseline risk assessment (RA) evaluates potential current and future adverse health effects caused by hazards (MEC) or hazardous substance (MC) releases from a site in the absence of any actions to control or mitigate these releases. In addition, the risk assessment evaluates the magnitude of the risk at the site and the primary causes of that risk. The baseline risk assessment does not include releases associated with actions taken to mitigate imminent hazards (e.g., detonations to remove MEC). The results of the risk assessment aid in the development, evaluation, and selection of appropriate response alternatives.

Baseline risk assessments are site-specific evaluations and may vary in both detail and extent to which qualitative and quantitative inputs are used. Generally, risk assessments follow a phased approach, starting with generic assumptions and moving toward a more complex site-specific evaluation as necessary. The characteristics of the risk assessment depend on the complexity and particular circumstances of the site as well as the availability of ARARs and other guidance. The risk assessments also consider the potential risks associated with current land use and activities, as well as reasonably anticipated future land use.

7.2 Potential for Adverse Effects from MC

The MC baseline risk assessment was conducted in accordance with *EPA Risk Assessment Guidance for Superfund (RAGS),* and USACE EM 200-1-4 *Risk Assessment Handbook.* The MC baseline risk assessment described in the following sections evaluates the potential for adverse effects on both human and ecological receptors associated with each exposure pathway. An exposure pathway is considered complete if there is a clear potential for human and/or ecological receptors to be exposed to a chemical hazard. The MC baseline risk assessment first identifies those constituents that require further evaluation in a SLRA. The MC baseline risk assessment then assesses the potential significance of complete exposure pathways (that is, whether there is an unacceptable risk). The objectives of this MC baseline risk assessment are to:

- Determine whether an unacceptable risk is present
- Provide a quantitative baseline human health risk assessment and an ecological risk assessment if unacceptable risks have been identified in baseline risk assessment screening steps.

The sections below discuss the protocols used in the baseline risk assessment. COPCs are site-related chemicals that have been retained for analysis in the baseline risk assessment. Chemicals of concern are those chemicals identified for consideration in a FS based on results of the baseline risk assessment.

7.2.1 Phased Risk Assessment Approach

The results of the prior investigations conducted for the Culebra Island MRSs were used to develop a sampling strategy for the RI. An initial characterization of the analytical data determined whether there was evidence of a release of contaminants at the MRSs. At the Culebra Island MRSs, explosives were not detected in any samples. For metals, a concentration greater than the PSV indicates a potential release has occurred. If the maximum detected concentration of a metal does not exceed its PSV, then there is no evidence of a release and further risk evaluation is not conducted for the analyte.

If evaluation of the data indicates that a release has likely occurred, a baseline risk assessment is conducted in a stepwise manner, moving from a relatively simple SLRA to a more complex deterministic risk assessment, as needed.

If a release was determined, the potential exposure pathways and potential receptors identified in the CSM were evaluated. If a release was indicated, and complete exposure pathways were identified, then representative concentrations of each metal found above PSV (these metals are now considered COPCs), were used to determine the potential for a human health or ecological risk.

7.2.2 Potential Exposure Pathways for Human and Ecological Receptors

The Culebra Island FUDS consists of 8,430 acres of land primarily privately owned with portions managed by the USFWS and DNER. All areas within the Culebra Island FUDS have unrestricted public access; however, vegetation and terrain are very restrictive and as such MRSs 06N, 06S, 08, 09, 11, and 13 are considered "limited restriction to access." Much of the island is accessed regularly by the 2,000-plus local residents and many yearly visitors. Potential human receptors for these sites include residents, recreational users, site visitors, construction workers, and commercial/industrial workers. Ecological receptors can also come into contact with MC. Although a biological survey has not been conducted within these MRSs, the area is likely to contain the typical fauna and flora associated with the islands of Puerto Rico (Section 2), including sensitive, threatened, and endangered species. Ecological receptors including sensitive and endangered species are considered present within all of these MRSs.

Potential exposure pathways to both human and ecological receptors are presented below. The MC CSM identifies affected media, transport mechanisms, exposure routes, and potential receptors; CSMs developed for each Culebra Island MRS are included in Chapter 5.

7.2.2.1 Surface Soil

- Direct release of MC from munitions activities would have been to surface soil. Potential exposure to MC contamination in surface soil typically occurs through the following pathways:
- Incidental ingestion of soil
- Dermal contact with soil
- Inhalation of re-suspended particulate matter from soil.

Potential human receptors which could interact with MC through the pathways mentioned above include residents, recreational users, site visitors, construction workers, and commercial/industrial workers.

Potential ecological receptors in these areas would potentially be exposed to MC through ingestion, dermal contact, and inhalation.

Wildlife and game species (i.e., feral hogs and deer) are present at the site, and have the potential of being exposed to MC while grazing or digging in the area.

7.2.2.2 Surface Water and Sediment

Due to runoff from the surrounding areas and the presence of aquatic habitats within MRS 09, surface water and sediment are present within this MRS. Potential exposure to MC contamination in surface water and sediment could occur through the following pathways:

- Incidental ingestion of surface water or sediment
- Dermal contact with surface water or sediment.

Similar to the soil pathways, potential human receptors that may encounter surface water and sediment through the course of their activities include residents, recreational users (e.g., hunters), visitors, construction workers, and commercial/ industrial workers.

Potential ecological receptors exist at MRS 09. Receptors in these areas would potentially be affected through the ingestion and dermal contact pathways.

7.2.2.3 Groundwater

MC present in soil has the potential to leach to a shallow aquifer. Potential exposure to MC in groundwater could occur through:

- Incidental ingestion of groundwater
- Dermal contact with groundwater.
- Ingestion of groundwater as drinking water

Potential human receptors include current and future residents and on-site workers who, during their activities on site, may encounter groundwater through the course of their activities. Additionally, construction workers could encounter groundwater during excavation activities. No potable wells are known to exist within the site that could expose receptors to the ingestion pathway. No restriction currently exists on installation of future wells, but all wells must receive an approved permit for installation.

Potential ecological receptors during their activities are not expected to access subsurface groundwater and are therefore are unlikely to encounter groundwater on-site.

7.3 MC Risk Evaluation

7.3.1 Screening Level Risk Assessment

Direct contact of residential receptors to soil through incidental ingestion, dermal contact, and inhalation of soil particulates and volatiles was used to develop conservative screening criteria.

The maximum detected concentrations of COPCs are compared to the residential soil screening levels to determine the potential for a human health risk. If the maximum detected concentration of the COPC does not exceed the screening value, it is assumed that there is no unacceptable risk and the risk assessment process is considered complete. Maximum detected concentrations of COPCs less than screening levels are not expected to pose an unacceptable risk to human receptors, including residential receptors. Because the screening levels are based on conservative exposure assumptions, even if a detected chemical is found at concentrations greater than the screening value, it does not necessarily indicate that an unacceptable risk is present.

To evaluate human health risk due to exposure to soil and groundwater, the maximum detected concentration of each COPC in each MRS is compared to the appropriate human health screening value. Cumulative carcinogenic risks and noncarcinogenic hazard quotients (HQ) will be calculated and evaluated for each COPC listed for human exposure to groundwater.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level or intake derived for a similar exposure period. The ratio of the exposure concentration to the noncarcinogenic toxicity value is the HQ. In other words, HQ equals the intake divided by the corresponding reference value: A HI in excess of 1 indicates the potential for noncarcinogenic health effects.

Carcinogenic risk is expressed as an increased probability of developing cancer as a result of lifetime exposure to a COPC. For simultaneous exposure to several carcinogens, USEPA assumes that risks are additive: USEPA's (1991) target carcinogenic risk management range for environmental remediation sites is one-in-one million (1E-06) to one-in-ten thousand (1E-04).

To evaluate ecological risk in soil for the site, the maximum detected concentration of each COPC is evaluated using the appropriate ecological screening value. This comparison results in the calculation of aHQ for each analyte. A HQ is calculated by determining the ratio of the representative concentration to the screening value. Calculated HQ values are rounded to the nearest whole number. If the HQ is equal to or less than one, the potential for ecological risk is considered to be negligible. If the HQ is greater than one, then unacceptable ecological risk should not be ruled out based on the screening comparison alone. An HQ greater than one is further reviewed to evaluate the significance of the exceedance.

7.3.2 Risk Evaluation

A risk evaluation was conducted for those COPCs identified in the characterization step. The MC baseline risk assessment evaluated the potential for adverse effects on both human and ecological receptors associated with each exposure pathway. In the following sections, COPCs that were identified for each MRS are evaluated in the following order:

- Site-by-site, medium-specific SLRAs were conducted.
- COPC concentrations for each medium at a site were evaluated first using human health screening values, then using ecological screening values (ESVs).
- Each COPC identified in the SLRA as exceeding human health or ESVs was then evaluated in more detail.
- As appropriate, past and present land uses were considered to determine if alternate screening values were applicable.

- The final step in the baseline risk assessment included quantitative risk calculations for those COPCs that were found to exceed relevant human health and/or ESVs and be attributable to former munitions use at the site.

7.3.3 MRS 06 North

Based on the soil source evaluation in Subsection 5.4.1.1, the maximum detected concentration of one metal, barium, was greater than its PSV. Soil sample (PR-1014-S-084) had a concentration (750 mg/kg) that exceeded the PSV (710 mg/kg). Thirteen additional samples were collected surrounding sample PR-1014-S-084 and analyzed for barium; of these 13 samples, five had concentrations that exceeded the PSV for barium.

The maximum detected concentration of barium (1,100 mg/kg) did not exceed the human screening value (1,500 mg/kg); therefore, no risk to human health is expected from exposure to soil at MRS 06N. The maximum detected concentration of barium in soil at MRS 06N was 1,100 mg/kg; this concentration exceeds the ESV for invertebrate receptors (EcoSSL = 330 mg/kg) resulting in a HQ of 3; the maximum concentration of barium does not exceed the ESV for mammals (EcoSSL = 2,000 mg/kg) and there is no published EcoSSL for plants or avian receptors. The maximum detected concentration of barium only slightly exceeds the background threshold value (710 mg/kg).

Soil sample PR-1014-S084 was collected at Grid 6-17; during the intrusive investigation phase of Grid 6-17, one item was classified as being MD. Although this piece was identified as a piece of rotating band, historical use of this portion of MRS 06 does not indicate that Grid 6-17 was located within an impact area. According to the ASR and ASR Supplement, there were no indications that firing points or military structures were located in the vicinity of Grid 6-17. Given that this item was the only MD recovered in Grid 6-17 and there is no documented military use at this grid, it is unlikely that the recovered MD indicates that Grid 6-17 was within an impact area. The 75mm M48 projectiles (the munitions with documented use at MRS 06), were not fired at the MRS, they were fired toward off island targets.. There is no indication that munition related contamination exists in this area. In addition, it should be noted that barium in the form of barium nitrate and to some degree barium chromate is used in munitions as a primary explosive (primers and fuzes). If a detonation had occurred the barium would be consumed. Based on the small quantities of MD found indicating no concentrated munitions use, it is unlikely that barium exceedances are indicative of DoD use. If munitions were the source other explosives related exceedances would have been present (i.e., TNT, lead, etc.).

During RI step-out sampling to delineate barium in PR-1014-S-084, a bulldozed berm of trash and construction debris was discovered adjacent to PR-1014-S-084. Since the piece of rotating band does not correlate with former activities at this MRS, the debris could be a remnant of the nearby trash pile. Therefore, barium is not considered to be related to former munitions use at MRS 06N and will not be evaluated further.

Based on the groundwater source evaluation, no analytes were detected exceeding their respective PSVs. Therefore, there is no evidence of a release of MC to groundwater at MRS 06 North and the site will not be further evaluated in the risk assessment.

7.3.4 MRS 06 South

Based on the soil source evaluation in Subsection 5.4.1.2, explosives were not detected in any soil samples and the maximum detected concentration of metals did not exceed their PSVs; therefore, soil in MRS 06S was not evaluated further in this risk assessment.

Based on the groundwater source evaluation, the maximum concentrations of one metal, chromium in the form of chromium (VI), exceeded its human health screening value and was evaluated in the risk assessment as a COPC. The exposure point concentration of chromium (VI) for comparison was determined per the rationale described in Section 4.2.8.4. Chromium was evaluated for both noncarcinogenic and carcinogenic effects.

Multiple receptors were identified in the CSM as having potentially complete groundwater exposure pathways at MRS 06 South. These receptors include: current/future residents, construction/excavation workers, and commercial/industrial workers. Risk results for each receptor are presented below. Tables with risk calculations are located in Appendix O.

Current / Future Resident

As presented in Table O.1, evaluation of ingestion of groundwater as drinking water results in a cancer risk of 2E-06 and a HQ of 0.002, indicating no expected unacceptable risk.

As presented in Table O.2, evaluation of dermal exposure to groundwater results in a cancer risk of 1E-06 and a HQ of 0.002, indicating no expected unacceptable risk.

Construction / Excavation Worker

Construction/excavation worker pathways include incidental ingestion and dermal exposure to groundwater.

As presented in Table O.3, the evaluation of incidental ingestion of groundwater results in a cancer risk of 4E-08 and a HQ of 0.0001, indicating no expected unacceptable risk.

As presented in Table O.4, the evaluation of dermal exposure to groundwater results in a cancer risk of 1E-07 and a HQ of 0.0002, indicating no expected unacceptable risk.

Commercial / Industrial Worker

Commercial/ industrial worker pathways included: incidental ingestion of groundwater and dermal exposure to groundwater.

As presented in Table O.5, the evaluation of incidental ingestion of groundwater results in a cancer risk of 1E-06 and a HQ of 0.002, indicating no expected unacceptable risk.

As presented in Table O.6, the evaluation of dermal exposure to groundwater resulted in a cancer risk of 7E-07 and a HQ of 0.001, indicating no expected unacceptable risk.

7.3.5 MRS 08

The 2007 SI results indicated that the concentration of zinc in soil exceeded its ecological screening value used in that report, generating an HQ of 1.8. However, the maximum detected concentration for zinc did not exceed the selected PSV used in this RI. Based on the soil source evaluation, explosives were not detected in any soil samples and the maximum detected concentration of metals did not exceed their PSVs; therefore, MRS 08 was not retained for further consideration in this risk assessment.

Based on the sediment source evaluation, the sediment/surface water exposure pathway is incomplete and is not considered further in this risk assessment.

Based on the groundwater source evaluation, the groundwater exposure pathway is incomplete for MRS 08 and will not be further evaluated in the risk assessment.

7.3.6 MRS 09

The 2007 SI results indicated that chromium exceeded its ecological screening value used in that report, generating an HQ of 48. However, when compared to the PSVs used in this risk assessment, chromium did not exceed the selected value. Based on the soil source evaluation, explosives were not detected in any soil samples and the maximum detected concentration of metals did not exceed their PSVs; therefore, the surface soil at MRS 09 was not retained for further consideration in this risk assessment.

Based on the surface water source evaluation, explosives were not detected in any surface water samples and the maximum detected concentration of metals did not exceed their PSVs. Therefore, the surface water at MRS 09 was not retained for further consideration in this RA.

Based on the sediment source evaluation, the maximum detected concentration of two metals, aluminum and copper, were greater than their PSV and sediment at this MRS was retained for further evaluation. Two sediment samples were collected at MRS 09 (PR-1012-SD-035 and PR-1012-SD-037). The concentration of aluminum was greater than the PSV in both samples; the concentration of copper was greater than its PSV in only one sample.

For sample PR-1012-SD-035, the maximum detected concentration of aluminum (68,000 mg/kg) exceeded the selected human health screening value (7,700 mg/kg). However, the selected human health screening value was determined by dividing the USEPA RSL by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. The maximum detected concentration of aluminum (68,000 mg/kg) does not exceed the unadjusted USEPA RSL (77,000 mg/kg).

Also in sample PR-1012-SD-035, the maximum detected concentration of copper (390 mg/kg) exceeded the selected human health screening value (310 mg/kg). However, the selected human health screening value for copper was also determined by dividing the USEPA RSL by 10 to reflect a HQ of 0.1 to account for potential cumulative effects. The maximum detected concentration of copper (390 mg/kg) does not exceed the unadjusted USEPA RSL (3,100 mg/kg).

Aluminum and copper are not carcinogens. The non-carcinogenic toxicological endpoints of aluminum (neurological) (ATSDR, 2008) and copper (gastrointestinal) (ATSDR, 2004) are not the same (i.e., they affect different target organs). Therefore, aluminum and copper are not expected to exert cumulative effects. Therefore, screening using the unadjusted RSLs is appropriate. An unacceptable risk to human health is not expected from exposure to aluminum and copper in sediment at MRS 09.

The maximum detected concentration of aluminum in sediment at MRS 09 (68,000 mg/kg) only slightly exceeds the background threshold value for soil (57,000 mg/kg) and the ecological screening value of 280 mg/kg resulting in a HQ of 240.

Two sediment samples were collected at MRS 09, the concentration of copper in one sample (390 mg/kg) slightly exceeds the BTV for copper in soil (310 mg/kg) and exceeds the ecological

screening value of 19 mg/kg resulting in a HQ of 21; the selected sediment ecological screening value of 19 mg/kg is the USEPA Region 4 ESV that is based on the threshold effect level applicable to Florida coastal waters, the probable effect level for Florida coastal waters is published as 108 mg/kg.

The naturally occurring concentration of aluminum and copper in Rs soils is high and sediment at MRS 09 was sampled in a collection lagoon that does not have an outfall or discharge in any way to other surface water bodies. Thus, it is likely that metals can be concentrated in the collection lagoon due to erosion from surrounding soils. During RI sampling activities, illegally dumped trash was observed in sediment at this site. Therefore, elevated concentrations of aluminum and copper in sediment may be a result of illegal dumping and concentration of metals in sediment, and may not be related to former munitions use at MRS 09. Therefore, based on the results of sampling conducted at this site and evaluation of the surrounding area, aluminum and copper are not considered COPCs in MRS sediment resulting from former munitions use and will not be evaluated further.

Based on the groundwater source evaluation, the maximum concentrations of two metals, chromium (VI) and copper, exceeded their human health screening values and were evaluated in the risk assessment as COPCs. The exposure point concentration of chromium (VI) was determined per the rationale described in Section 4.2.8.4. Copper was evaluated for noncarcinogenic effects; and chromium was evaluated for both noncarcinogenic and carcinogenic effects.

Multiple receptors were identified in the CSM as having potentially complete groundwater exposure pathways at MRS 09. These receptors include: current/future residents, construction/excavation workers, and commercial/industrial workers. Risk results for each receptor are presented below. Tables with risk calculations are located in Appendix O.

Current/ Future Resident

As presented in Table O.7, evaluation of ingestion of groundwater as drinking water results in a cumulative cancer risk of 3E-07 and a Hazard Index (HI) of 0.1, indicating no expected unacceptable risk. The HI represents the cumulative risk for all COPCs detected above screening levels in groundwater within the MRS.

As presented in Table O.8, evaluation of dermal exposure to groundwater results in a cancer risk of 2E-07 and a HQ of 0.001, indicating no expected unacceptable risk.

Construction/ Excavation Worker

Construction/excavation worker pathways include incidental ingestion and dermal exposure to groundwater.

As presented in Table O.9, the evaluation of incidental ingestion of groundwater results in a cancer risk of 7E-09 and a HQ of 0.003, indicating no expected unacceptable risk.

As presented in Table O.10, the evaluation of dermal exposure to groundwater results in a cancer risk of 2E-08 and a HQ of 0.0002, indicating no expected unacceptable risk.

Commercial/ Industrial Worker

Commercial/ industrial worker pathways included: incidental ingestion of groundwater and dermal exposure to groundwater.

As presented in Table O.11, the evaluation of incidental ingestion of groundwater results in a cancer risk of 2E-07 and a HQ of 0.09, indicating no expected unacceptable risk.

As presented in Table O.12, the evaluation of dermal exposure to groundwater resulted in a cancer risk of 1E-07 and a HQ of 0.0009, indicating no expected unacceptable risk.

7.3.7 MRS 11

Based on the soil source evaluation in Subsection 5.4.1.5, the maximum detected concentration of one metal, mercury, was greater than its PSV. Only one sample (PR-1011-S-008) had a concentration (0.4 mg/kg) that exceeded the PSV (0.1 mg/kg). Three additional samples were collected west of sample PR-1011-S-008, but none of these had concentrations that exceeded the PSV. Additional samples were proposed to be collected north, east, and south of sample PR-1011-S-008, but ROE was not obtained for that property.

The maximum detected concentration of mercury (0.4 mg/kg) did not exceed the human health screening value (1.0 mg/kg); therefore, no risk to human health is expected from exposure to soil at MRS 11. However, the maximum detected concentration of mercury does exceed the ecological screening value of 0.1 mg/kg for mercury resulting in a HQ of 4. Mercury is used in munitions in the form of mercury fulminate in very small quantities as a primary explosive and is completely consumed in a detonation. Based on no MEC and very limited quantities of MD, is is unlikely the mercury exceedances resulted from DoD use of the island. As previously described, the island municipal landfill is located on the northern portion of MRS 11 in close proximity to soil sample PR-1011-S-008. The landfill is unlined and contains items such as fluorescent light bulbs, appliances, and electronics. Mercury that leached from the landfilled items was likely transported via overland flow and is likely the source that contributed to the mercury detected in soil at this site. Therefore, mercury in soil is not considered to be related to former munitions use at MRS 11 and will not be considered further.

Based on the groundwater source evaluation, the maximum concentration of one metal, chromium, exceeded its human health screening value and was evaluated in the risk assessment as a COPC. Chromium was evaluated for both noncarcinogenic and carcinogenic effects.

Multiple receptors were identified in the CSM as having potentially complete groundwater exposure pathways at MRS 11. These receptors include: current/future residents, construction/excavation workers, and commercial/industrial workers. Risk results for each receptor are presented below. Tables with risk calculations are located in Appendix O.

Current/ Future Resident

As presented in Table O.13, evaluation of ingestion of groundwater as drinking water results in a cancer risk of 1E-06 and a HQ of 0.002, indicating no expected unacceptable risk.

As presented in Table O.14, evaluation of dermal exposure to groundwater results in a cancer risk of 6E-07 and a HQ of 0.001, indicating no expected unacceptable risk.

Construction/ Excavation Worker

Construction/excavation worker pathways include incidental ingestion and dermal exposure to groundwater.

As presented in Table O.15, the evaluation of incidental ingestion of groundwater results in a cancer risk of 2E-08 and a HQ of 0.00004, indicating no expected unacceptable risk.

As presented in Table O.16, the evaluation of dermal exposure to groundwater results in a cancer risk of 8E-08 and a HQ of 0.0001, indicating no expected unacceptable risk.

Commercial/ Industrial Worker

Commercial/ industrial worker pathways included: incidental ingestion of groundwater and dermal exposure to groundwater.

As presented in Table O.17, the evaluation of incidental ingestion of groundwater results in a cancer risk of 7E-07 and a HQ of 0.001, indicating no expected unacceptable risk.

As presented in Table O.18, the evaluation of dermal exposure to groundwater resulted in a cancer risk of 4E-07 and a HQ of 0.001, indicating no expected unacceptable risk.

7.3.8 MRS 13

The 2007 SI results indicated that chromium exceeded its ecological screening value used in that report, generating an HQ of 42.5. However, when compared to the PSVs used in this risk assessment, the maximum detected concentration for chromium did not exceed the selected value. Based on the soil source evaluation, explosives were not detected in any soil samples and the maximum detected concentrations of eight metals were not greater than their PSVs. One metal, iron, had a maximum detected concentration that exceeded the PSV, but iron is an essential nutrient and was not retained for further evaluation. Therefore, MRS 13 was not retained for further consideration in this risk assessment.

Based on the groundwater source evaluation, the groundwater exposure pathway is incomplete for MRS 13 and will not be further evaluated in the risk assessment.

Therefore, MRS 13 was not retained for further consideration in the risk assessment.

7.4 CONCLUSIONS OF THE MC RISK ASSESSMENT

The results of the baseline risk assessment are presented in the following sections.

7.4.1 MRS 06N

Based on the results of this RI and a review of the MC risk assessment objectives, there is no unacceptable risk attributable to former munitions-related activities at the site. No evidence of concentrated munitions use was observed, and therefore no source of MC is present.

No unacceptable risk to Human Health is expected to occur from exposure to soil, surface water, sediment, or groundwater at MRS 06N.

Based on the analytical results presented in this report, barium was detected in surface soil slightly above its ecological screening value for invertebrate receptors. Since barium is not a component of munitions documented on site and no evidence of concentrated munitions use was observed, a trash pile observed near the sampling location is the likely source. No unacceptable risk to ecological receptors attributable to MC is expected to occur from to exposure to soil, or surface water. A small risk is present to ecological receptors due to a non-munitions related source of barium.

No unacceptable risk is expected to occur at MRS 06N due to exposure to groundwater.

7.4.2 MRS 06S

Based on results of this RI and a review of the MC risk assessment objectives, there is no unacceptable risk to human health or ecological receptors from exposure to soil at MRS 06S within Culebra Island site. No unacceptable risk is expected to occur at MRS 06S due to exposure to groundwater.

7.4.3 MRS 08

Based on results of this RI and a review of the MC risk assessment objectives, there is no unacceptable risk to human health or ecological receptors from exposure to soil or sediment at MRS 08 within Culebra Island site. No perennial surface water is present and the groundwater pathway is incomplete.

7.4.4 MRS 09

Based on results of this RI and a review of the MC risk assessment objectives, there is no unacceptable risk attributable to former munitions-related activities at the site. No evidence of concentrated munitions use was observed, and therefore no source of MC is present.

No unacceptable risk to Human Health is expected to occur due to exposure to soil, surface water, or sediment at MRS 09.

Based on the analytical results presented in this report, aluminum and copper were detected in sediment above their ecological screening value. However, the naturally occurring concentrations of aluminum and copper in the Rs soil type (from which the sediment is derived) are high and the detected concentrations only slightly exceeded these background levels. Thesediment at MRS 09 was sampled in a collection lagoon that does not have an outfall or discharge in any way to other surface water bodies. Thus, it is possible that metals can be concentrated in the collection lagoon due to erosion from surrounding bedrock and soils. During RI sampling activities, illegally dumped trash was observed in the lagoon where the sediment was collected. Since no evidence of concentrated munitions use was observed, the elevated detections of aluminum and copper in sediment are likely a result of the illegal dumping,and are likely not related to former munitions use at MRS 09. Therefore, based on the results of sampling conducted at this site and evaluation of the surrounding area, aluminum and copper are not considered to pose an unacceptableMC in site sediment.

No unacceptable risk to ecological receptors attributable to MC is expected to occur from exposure to sediment. A small risk is present to ecological receptors due to non-DoD sources of aluminum and copper.

No unacceptable risk is expected to occur at MRS 09 due to exposure to groundwater.

7.4.5 MRS 11

Based on results of this RI and a review of the MC risk assessment objectives, no unacceptable risk is present attributable to former munitions-related activities at the site. No evidence of concentrated munitions use was observed, and therefore no source of MC is present.

No unacceptable risk to Human Health attributable to MC is expected to occur from to exposure to soil, surface water, sediment at MRS 11.

Based on the analytical results presented in this report, mercury detected in surface soil slightly above its ecological screening value is likely related to the leachate transported by overland flow from the nearby municipal landfill at MRS 11. No unacceptable risk to ecological receptors attributable to MC is expected to occur from to exposure to soil, surface water, or sediment. A slight risk is present to ecological receptors due to non-DoD sources of mercury.

No unacceptable risk is expected to occur at MRS 11 due to exposure to groundwater.

7.4.6 MRS 13

Based on results of this RI and a review of the MC risk assessment objectives, there is no unacceptable risk to human health or ecological receptors from exposure to soil at MRS 13 within the Culebra Island site.

7.4.7 MC Uncertainty Assessment

7.4.7.1 Uncertainty in Data Collection and Evaluation

The analysis of uncertainties related to data collection and evaluation focuses on determining whether the available data are representative of site concentrations and site conditions, and whether the features of sampling, analyses, or statistical treatment of the data result in an over- or under estimation of potential risk. The following list addresses potential areas of uncertainty.

- Analytes that were never detected were eliminated from the risk assessment.

It is possible that some MC may have been present in samples below the reporting limit and not retained in the RA. However, since samples were collected from areas where concentrations were expected to be the highest based on the MEC investigation, and because maximum values were used in comparisons, it is unlikely that any MC were present at health-significant levels.

- Analytes that were below screening levels.

It is possible some analytes may be present onsite in concentrations higher than the screening levels in areas that that were not sampled. These areas could be areas outside the locations called for in the DQOs, or in areas where ROE was not obtained. However, based on analysis of historical information and the MEC investigation, we feel the risk attributable to former munitions use is characterized correctly.

- Representation of background screening levels could be higher or lower than estimated.

To account for this the mean background concentration was multiplied by a factor of 2.

- The RI concluded that the ecological exceedances were not from munitions related sources. Therefore, the exceedances were not carried further in risk assessment.

It is possible that burrowing animals could be exposed to analyte exceedances in the very scarce subsurface soil present onsite.

7.4.7.2 Uncertainty in Toxicity Assessment (Groundwater Only)

Some uncertainty is also inherent in the toxicity values used in the groundwater HHRA. Carcinogenic slope factors and route-specific values are derived only for compounds that have been shown to cause an increased incidence of tumors in either human or animal studies. This

dose-response curve is then assumed to be linear at low doses (e.g., those found in situations of environmental contamination) and is used to predict tumor incidence at low exposure levels. When an animal study is used, the final SF is adjusted to account for extrapolation of animal data to humans. If the studies used to derive the SF were conducted for less than the life span of the test organism, the final SF had also been adjusted to reflect risk associated with lifetime exposure.

The carcinogenic slope factors are generally an upper 95th percentile confidence limit of the probability of a response based on experimental animal data in the multistage model. This means that the site-specific chemical risk is not likely to exceed the risk estimate derived through the model and is likely to be less than the predicted risk.

The chronic reference dose (RfD) for a compound is based on studies where either human or animal populations were exposed to a given compound by a given route of exposure for the major portion of the life span (as an USEPA guideline, 7 years to a lifetime) (USEPA, 1989). RfDs are derived by determining dose-specific effect levels from all the available quantitative studies and applying uncertainty factors to the most appropriate effect level to determine an RfD for humans. Uncertainty factors are generally applied as multiples of 10 to represent specific areas of uncertainty in the data. Typically, an uncertainty factor of 100 to 1,000 is used in the professional judgment of uncertainties. General uncertainties in the derivation of RfDs may be associated with factors such as: (1) variations in the general population (to protect sensitive receptors); (2) extrapolation of animal data to humans; (3) use of a subchronic study versus a chronic study to determine the no-observed-adverse-effect level (NOAEL); or (4) use of a lowest-observed-adverse-effect level (LOAEL) versus a NOAEL. Both the uncertainty and modifying factors are conservative in nature and tend to overestimate risk.

7.4.7.3 Uncertainty in Estimating Chemical Risk

The expression of the potential risk associated with contaminants detected at the site is a result of the combined steps of data evaluation, exposure assessment, and toxicity assessment. This combination provides the potential to magnify the uncertainties present in these steps of the HHRA process.

However, screening criteria are developed using very conservative (health-protective) exposure and intake assumptions. The HHRA comparisons also use conservative concentrations of the chemicals detected at the site. Additionally, screening criteria used in the HHRA are considered health-protective for carcinogenic and non-carcinogenic chemical mixtures. Carcinogenic chemicals correspond to the conservative 1×10^{-6} (one in a million) excess cancer risk level, providing a very protective screening value. Non-carcinogens use a target HQ of 1.

7.4.8 Conclusion

Based on the results of the risk assessment for Culebra Island and the analysis of uncertainty, there is no unacceptable risk to human health or ecological receptors attributable to former munitions-related activities at any of the MRSs evaluated in this RI at Culebra Island.

7.5 Risk Characterization For MEC

A baseline MEC Hazard Assessment (MEC HA) was completed for the Culebra Island MRS using the MEC HA guidance and accompanying automated scoring worksheets (Appendix K).

The MEC HA addresses the NCP direction for site-specific assessment of risks to human health and the environment. The MEC HA helps a project team understand the hazards associated with a MRS if no action is taken, and to evaluate the hazard reductions associated with removal or remedial alternatives. As with any CERCLA-based cleanup process, several different alternatives may be protective of human health and the environment. The information collected for the MEC HA as well as the results can provide input into the CERCLA remedy evaluation and selection process in the FS phase. The MEC HA presents a number of input factors that are scored based on current site conditions (baseline) and rescored based on proposed remedial alternatives during the FS phase. Based on the input factors for each MRS, the scoring worksheets generate a score for the site based on a sum of the scores determined for each input factor. The sum of the input factor scores falls within one of four hazard levels (1–4). The following description of each hazard level is summarized from the Interim MEC HA Methodology (USEPA, 2008):

Hazard Level 1

This category identifies sites with the highest potential explosive hazard conditions. There may be instances where there is an imminent threat to human health from MEC. This hazard may be so obvious that an emergency response is appropriate without calculating a MEC HA.

Typical characteristics of a Hazard Level 1 site condition include a combination of the following:

- High-explosive-filled UXO, usually "Sensitive UXO" on the surface
- A former target area or OB/OD area
- An MRS with full or moderate accessibility
- Has the presence of additional human receptors inside the MRS or Explosive Safety Quantity-Distance (ESQD)
- May include subsurface MEC with intrusive activities to the depth of subsurface MEC
- An MRS that has not undergone a cleanup.

Hazard Level 2

This Hazard Level identifies MRS with high potential explosive hazard conditions. Typical characteristics of a Hazard Level 2 MRS include the following:

- Former target area, OB/OD area, function test range, or maneuver area
- UXO, or Fuzed Sensitive DMM on the surface, or intrusive activities that overlap with minimum depths of UXO or Fuzed Sensitive DMM located only subsurface
- Has full or moderate accessibility to people who will engage in intrusive activities.

Hazard Level 3

This Hazard level identifies MRS with moderate potential explosive hazard conditions. Typical characteristics of a Hazard Level 3 MRS include the following:

- DMM on the surface, or intrusive activities that overlap with minimum depths of DMM located only subsurface
- Former target area, OB/OD area, function test range, or maneuver area that has undergone a surface cleanup

- An MRS with moderate or limited accessibility, and a low number of contact hours.

Hazard Level 4

This Hazard Level identifies MRS with low potential explosive hazard conditions. The presence of MEC at an MRS means that an explosive hazard may exist. Therefore, MEC may still pose a hazard at a Hazard Level 4 MRS. Typical characteristics of an MRS in Hazard Level 4 include the following:

- A MEC cleanup was performed or MEC is only located subsurface, below the depth of receptor intrusive activities
- Energetic Material Type is propellant, spotting charge, or incendiary
- Accessibility is Limited or Very Limited, and contact hours are few or very few. This may be the result of Land Use Controls (LUCs).

LUCs may be required to reduce the MEC hazard level to support the reasonably anticipated land use. As an example, a MRS may be a Hazard Level 3 without LUCs but a Hazard Level 4 with LUCs.

7.5.1 Baseline Scoring Results

A baseline MEC HA was prepared for the Culebra Island MRS based on current site conditions and anticipated future activities. The MEC HA workbooks for each MRS are included as Appendix K. The following paragraphs discuss the baseline MEC HA scores for each MRS.

7.5.1.1 MRS 06 Artillery Firing Area

A baseline MEC HA was prepared for MRS 06 based on current site conditions and anticipated future activities. The MEC HA workbook is included as Appendix K. Based upon current site conditions following the RI/FS field effort, MRS 06 scored a 730, which corresponds to a Hazard Level 3.

7.5.1.2 MRS 08 Cayo Norte Impact Area

A baseline MEC HA was prepared for MRS 08 based on current site conditions and anticipated future activities. The MEC HA workbook is included as Appendix K. Based upon current site conditions following the RI/FS field effort, MRS 08 scored an 850, which corresponds to a Hazard Level 1.

7.5.1.3 Mrs 09 Soldado Point Mortar and Bombing Area

A baseline MEC HA was prepared for MRS 09 based on current site conditions and anticipated future activities. The MEC HA workbook is included as Appendix K. Based upon current site conditions following the RI/FS field effort, MRS 09 scored a 920, which corresponds to a Hazard Level 1.

7.5.1.4 MRS 10 Defensive Firing Area No. 1

A baseline MEC HA was prepared for MRS 10 based on current site conditions and anticipated future activities. The MEC HA workbook is included as Appendix K. Based upon current site

conditions following the RI/FS field effort, MRS 10 scored a 460, which corresponds to a Hazard Level 4.

7.5.1.5 MRS 11 Defensive Firing Area No. 2

A baseline MEC HA was prepared for MRS 11 based on current site conditions and anticipated future activities. Intrusive investigations within the southern portion of MRS 11 yielded no MEC or MD finds; however, five grids located in the northernmost portion of MRS 11 did yield MD. These five grids are located adjacent to the NWP area. The MEC HA workbook is included as Appendix K. Based upon current site conditions following the RI/FS field effort, MRS 11 scored an 840, which corresponds to a Hazard Level 1.

7.5.1.6 MRS 13 Cayo Luis Pena Impact Areas

A baseline MEC HA was prepared for MRS 13 based on current site conditions and anticipated future activities. The MEC HA workbook is included as Appendix K. Based upon current site conditions following the RI/FS field effort, MRS 13 scored an 850, which corresponds to a Hazard Level 1.

7.5.2 Munitions Response Site Prioritization Protocol

A Munitions Response Site Prioritization Protocol (MRSPP) was prepared for all six of the Culebra Island MRSs as part of the SI Report (Parsons, 2007). Since additional data were collected, the MRSPP provided in the SI Report was re-evaluated and updated in this RI/FS Report to reflect the current understanding of site conditions. The latest version of the MRSPP worksheets was utilized. Table 7-1 provides a summary the MRSPP scored from the 2007 SI Report. Table 7-2 provides a summary of the revised MRSPP results for the Culebra Island MRSs. The revised MRSPP worksheets for the Culebra Island MRSs are provided in Appendix L.

Table 7-1: Summary of the 2007 SI MRSPP

MRS	EHE Rating	CHE Rating	HHE Rating	Overall Rating
06	C	No Known or Suspected CWM Hazard	D	5
08	B	No Known or Suspected CWM Hazard	F	3
09	C	No Known or Suspected CWM Hazard	G	4
10	C	No Known or Suspected CWM Hazard	D	4
11	C	No Known or Suspected CWM Hazard	G	4
13	C	No Known or Suspected CWM Hazard	G	4

Table 7-2: Summary of Revised MRSPP

MRS	EHE Rating	CHE Rating	HHE Rating	Overall Rating
06	E	No Known or Suspected CWM Hazard	E	6
08	B	No Known or Suspected CWM Hazard	No Known or Suspected MC Hazard	3
09	A	No Known or Suspected CWM Hazard	No Known or Suspected MC Hazard	2
10	G	No Known or Suspected CWM Hazard	No Known or Suspected MC Hazard	8
11	A	No Known or Suspected CWM Hazard	No Known or Suspected MC Hazard	2
13	A	No Known or Suspected CWM Hazard	No Known or Suspected MC Hazard	2

7.6 MEC HAZARD ASSESSMENT SUMMARY

The potential risk to public safety associated with MEC hazards was characterized for the Culebra Island MRSs. The potential explosive safety risk at MRSs 06, 08, 09, 10, 11, and 13 are based on their respective MEC HA baseline condition hazard level scores. This characterization is based on current site conditions. If conditions change, the characterization needs to be reevaluated. The information provided in this chapter will be used to provide a baseline characterization for the evaluation of alternatives provided in the FS Report.

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CHAPTER 8. SUMMARY OF RESULTS

8.1 INTRODUCTION

From June 2008 through May 2010, USA conducted an RI at the Culebra Island MRSs. The RI was developed to identify risks related to MEC and MC within all areas of the sites. The results of the investigation will be provided as an addendum to this report.

8.2 OBJECTIVES

The RI was conducted to evaluate the nature and extent of MEC that might be present within the boundaries of MRS 06, MRS 08, MRS 09, MRS 10, MRS 11, and MRS 13 on Culebra Island. The evaluation of MEC also considered the type and extent of MD found at the site. The nature and extent of MC that might be present at or around MEC/MD was investigated.

8.3 ACTIVITIES AND RESULTS

In support of the RI objectives, MC sampling, DGM, intrusive investigation of select anomalies, and mag-and-dig were conducted. MD was found at MRSs 06, 08, 09, 11, and 13, but not at MRS 10. Two MEC items were recovered in MRS 09 (two Mk 25 Marine Marker Flares). MD was found at 49 intrusively investigated locations. Additionally, MD found in a 2009 site visit was included in the analysis for MRS 13. MD consisted of a variety of practice bombs; ground-fired munitions, and naval and ground artillery projectiles. The RI data were found to be consistent with the various historical uses of the former Culebra Island MRSs. MD concentration and distribution within the range areas were found to be consistent with the historical documentation of firing points and target locations.

Environmental samples were collected in soil, surface water, and sediment. Soil samples were collected at locations associated with MEC and MD locations and at locations before and after detonations. Background surface soil samples were collected within nine soil types for use in determining background metals concentrations. The soil samples were analyzed for explosives and MC metals. Background surface water samples were collected from Cornello Lagoon in MRS 11. Surface water and sediment samples were collected from the lagoon located behind Sueno Cove in MRS 09. Groundwater samples were collected from wells in MRS 06, MRS 09, and MRS 11. All samples were analyzed in accordance with the QAPP approved at time of collection.

An evaluation of the need for cleanup action alternatives must be demonstrated through the use of either quantitative or qualitative risk assessments. A baseline RA evaluates potential current and future adverse health effects caused by hazards (MEC) or hazardous substance (MC) releases from a site in the absence of any actions to control or mitigate these releases. In addition, the RA evaluates the magnitude of the risk at the site and the primary causes of that risk. The baseline RA does not include releases associated with actions taken to mitigate imminent hazards (e.g., detonations to remove MEC). The results of the RA aid in the development, evaluation, and selection of appropriate response alternatives.

The MC RA presented the information required to evaluate the potential for adverse effects on both human and ecological receptors associated with each exposure pathway. It identified those constituents that required further evaluation in a SLRA and assessed the potential significance of

completed pathways (that is, whether there was an unacceptable risk). The objectives of this MC RA were to:

- Determine if there is evidence of a release of a contaminant at the site
- If a release has occurred, determine whether an unacceptable risk is present
- Provide a quantitative baseline human health RA and/or ecological RA if unacceptable risks have been identified in baseline RA screening steps.

One of the steps of an RI includes an evaluation of the risks associated with potential MC releases at a site. The objectives of the RA were presented at the beginning of this section.

8.4 CONCLUSIONS

The data collected during the RI sufficiently characterized the Culebra Island MRSs (MRSs 06, 08, 09, 10, 11, and 13) in accordance with the project DQOs. The data were used to support an approach as agreed upon by the TPP team. The MEC HA noted that there is a potential for human receptors to come into contact with MEC at the following MRSs:

- MRS 08 CAYO NORTE IMPACT AREA
- MRS 09 SOLDADO POINT MORTAR AND BOMBING AREA
- MRS 11N DEFENSIVE FIRING AREA NO. 2 (North)
- MRS 13 CAYO LUIS PENA IMPACT AREAS.

Based on the data collected by the RI, MRSs 06 and 10 do not have a significant MEC hazard; however, potential exposure to an explosive hazard cannot be completely ruled out due to the historical DoD use.

Based on the results of the MC risk assessment for Culebra Island, there is no unacceptable risk to human health or ecological receptors attributable to former munitions-related activities at any of the MRSs at Culebra Island. No unacceptable risk to human health was detected. Ecological exceedences detected were attributed to non-DoD sources. No further Action is recommended for MC.

Based on the finding of a significant MEC hazard for MRSs 08, 09, 11, and 13, a Feasibility Study is recommended to assess response action alternatives for managing risk associated with potential human interaction with MEC. Since an explosive hazard cannot be completely ruled out for MRSs 06 and 10, they will also be evaluated in the Feasibility Study.

As noted earlier, the conclusions and recommendations of this report apply only to the terrestrial portions of the six MRSs addressed in this RI.

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